THE FEASIBILITY OF EXERGAMING TO IMPROVE POSTURAL CONTROL IN COMMUNITY-DWELLING OLDER ADULTS

R. A. Tahmosybayat

PhD

2019

THE FEASIBILITY OF EXERGAMING TO IMPROVE POSTURAL CONTROL IN COMMUNITY-DWELLING OLDER ADULTS

ROBIN ARASH TAHMOSYBAYAT

A thesis submitted in partial fulfilment of the requirements of the University of Northumbria at Newcastle for the degree of Doctor of Philosophy

Research undertaken in the Faculty of Health and Life Sciences

May 2019

Declaration

I declare that the work contained in this thesis has not been submitted for any other award and that it is all my own work. I also confirm that this work fully acknowledges opinions, ideas and contributions from the work of others.

Any ethical clearance for the research presented in this thesis has been approved. Approval has been sought and granted by the University Ethics Committee.

I declare that the Word Count of this Thesis is as follows:

Main document – 72,573 words

Including references and appendices – 175,561 words

Name: Robin Tahmosybayat

Signature:

Original hand-in date: 1st of November 2018

Corrected thesis hand-in date: 13th of May 2019

Final electronic copy hand-in date: 4th of June 2019

Acknowledgments

I would like first and foremost like to thank my director of studies, Dr Gill Barry, for being a legend and for her constant belief and support throughout my Ph.D. process and her invaluable guidance throughout the process. I am also extremely grateful to my three supervisors – Dr Katherine Baker, Dr Alan Godfrey and Professor Nick Caplan – for their encouragement, guidance and fantastic mentorship though out my Ph.D. process, during which I am eternally grateful to have been given the opportunity to work and develop a great multidisciplinary research team.

I would like to acknowledge and thank Gemma Wilson for her qualitative expertise and support throughout the Ph.D. process, and thank you to all of the participants at Northumbria University, Gateshead Older Peoples Association and within the North East who kindly volunteered to take part in this study.

I would like to thank my fellow Ph.D. researchers within the Department of Sport, Exercise and Rehabilitation for all of their support and encouragement throughout the process.

Finally, I would like to thank my family and friends for their constant support and encouragement throughout the Ph.D. With special thanks to a good friend Ana for supporting me throughout the Ph.D. process from day one.

Current publications

Tahmosybayat, R., Baker, K., Godfrey, A., Caplan, N. & Barry, G. 2017. A systematic review and meta-analysis of outcome measures to assess postural control in older adults who undertake exergaming. *Maturitas,* 98**,** 35-45.

Tahmosybayat, R., Baker, K., Godfrey, A., Caplan, N. & Barry, G. 2018. Movements of older adults during exergaming interventions that are associated with the Systems Framework for Postural Control: A systematic review. *Maturitas,* 111**,** 90-99.

Publications under review

Tahmosybayat, R., Barry, G., Baker, K., Godfrey, A., Caplan, N., Wilson, G. Exergames across the ages: an exploration of usability and acceptance. *Human Computer Interaction*, 2018.

Manuscripts in preparation

Tahmosybayat, R., Baker, K., Godfrey, A., Caplan, N. & Barry, G. The MirEX trial – a feasibility trial with a tailored exergame to improve postural control in community-dwelling older adults. *The Gerontologist.* 2019

Tahmosybayat, R., Baker, K., Godfrey, A., Caplan, N. & Barry, G. Evaluation of the MirEX trial – perceptions of a tailored exergame and a community based fall prevention class among older adults beginning to fall. *Health Technology Assessment.* 2019

Conference abstracts

Tahmosybayat, R., Baker, K., Godfrey, A., Caplan, N., Barry, G. A systematic review and meta-analysis of outcome measures to assess postural control in older adults who

undertake exergaming. International Society of Posture and Gait Research World Congress, Fort Lauderdale, USA, 2017.

Tahmosybayat, R., Baker, K., Godfrey, A., Caplan, N., Barry, G. Exergaming to improve postural control in community-dwelling older adults – a feasibility trial with a tailored exergame. BASES Student Conference, Northumbria University, 12-13th April, 2018.

Tahmosybayat, R., Barry, G., Baker, K., Godfrey, A., Caplan, N., Wilson, G. Exergaming for younger and older adults – acceptance and usability of the Kinect™ and the Wii™. Physiotherapy Research Society Conference, Northumbria University, 19th April, 2018.

Tahmosybayat, R., Baker, K., Godfrey, A., Caplan, N., Barry, G. Exergames, postural control and preventing falls in the community – is it feasible? EU Falls Festival, University of Manchester, 2nd – 3rd July, 2018.

Tahmosybayat, R., Baker, K., Godfrey, A., Caplan, N., Barry, G. Move well: design deficits in postural based exergames. What are we missing? IEEE Games, Entertainment and Media Conference, The National University of Ireland Galway. 15th-17th August, 2018.

Abstract

Objective: This thesis reports on the design, development and implementation of a feasibility study to investigate if a tailored exergame could be implemented to improve postural control outcomes for community-dwelling older adult fallers living in the North East of England, UK. Design: This feasibility study was carried out in several phases according to the Medical Research Council (MRC) framework guidance for complex interventions. Phase1 consisted of two systematic reviews to identify characteristics to aid in the design, development and implementation of the intervention and subsequent pilot study and also to identify potential outcome measures. This also included a qualitative study of participants' perspectives using focus groups. Phase 2 consisted of a non-randomised controlled study where participants, recruited from 2 sites, Northumbria University and Gateshead Older Peoples Association (GOPA), were allocated to either one of two intervention groups (exergaming or traditional balance training) or a no exercise control group. The intervention lasted for 6 weeks and outcomes were assessed prior to the start of the intervention and following the final training session. Follow up interviews were conducted with participants and analysed using deductive thematic analysis. Findings: After reviewing the existing evidence, the literature indicated that exergaming interventions were as beneficial as traditional balance interventions, although the evidence for each outcome was of low quality, assessed using the GRADE approach. No intervention had implemented an outcome measure that assessed reactive postural control, verticality or the cognitive influences on postural control, such as the Mini-Balance Evaluation Systems Test (Mini-BESTest) and not all components of postural control were trained. Thematically analysed data from 3 focus groups totalling 13 participants, deduced four main themes: 1) attitudes toward technology, 2) consideration of balance and movement,

3) ease of use, and 4) social influence and exergaming. Adults of all ages perceived exergames to be enjoyable, yet, there were perceived barriers in using commercial exergames for older adults and individuals with balance impairments. The non-randomised pilot intervention took place in Newcastle and Gateshead, UK. Thirty-five participants (10 exergaming, 10 traditional balance training and 10 controls) were included in the study. All four of the progression criteria were met in that 69% of eligible participants were screened and allocated to the intervention with a retention rate of 95.7% for all assessments. Adherence was 100% successful and only 1 adverse event occurred (3%) and did not occur during any of the training or assessment visits. Analysis of interview data from 10 participants (5 exergaming, 5 traditional balance training) following the pilot intervention revealed that older adult fallers accept the use of a tailored exergame (Mira™) as a method to train postural control. Conclusions: A tailored exergaming intervention was successfully implemented and received well by participants, although amendments to the protocol and barriers to future participation for older adult fallers should be considered prior to implementing a future definitive trial.

Abbreviations

ABC – Activities specific Balance Confidence Scale

ADLs – Activities of Daily Living

AE - Autotelic experience

AP - Anteroposterior

AM - Action-awareness-merging

ANOVA – Analysis of Variance

ANCOVA – Analysis of Covariance

BESTest – Balance Evaluation Systems Test

BBS – Berg Balance Scale

BI - Behavioural intention

BoS – Base of Support

BWM – Body Worn Monitor

CB - Challenge-skill balance

CG - Clear goals

CoP - Centre of pressure

CoG – Centre of Gravity

CoM – Centre of Mass

CT - Concentration of task

EE - Effort expectancy

FACIT – Functional Assessment of Chronic Illness

FES – Falls Efficacy Scale

FES-I – Falls Efficacy Scale International

FC - Facilitating conditions

FRT – Functional Reach Test

FSS - Flow state scale

GDS – Geriatric Depression Scale

GOPA – Gateshead Older People Assembly

GRADE - Grading of Recommendations, Assessment, Development and Evaluations

LS - Loss of self-consciousness

MirEX – Mira Exergaming

ML - Medial-lateral

MMSE – Mini-Mental State Examination

MRC – Medical Research Council

MS – Multiple Sclerosis

PACES – Physical Activity Enjoyment Scale

PD – Parkinson’s Disease

PC - Paradox of control

PE - Performance expectancy

R - Multiple correlation coefficient

R2 - Squared multiple correlation coefficient

SD - Standard deviation

SI - Social influences

SF-36 – Standard Form 36

SFPC – Systems Framework for Postural Control

TUG – Timed Up and Go

TUGDT – Timed Up and Go Dual Task

TT - Transformation of time

UF - Unambiguous feedback

UTAUT - Unified Theory of Acceptance and Use of Technology

Glossary of Terminology

The information in the glossary of terminology refers to frequent use of terms in the thesis.

Anticipatory postural control – Ability to shift the centre of mass before a discrete voluntary movement (eg, stepping-lifting leg, arm raise, head turn) (Sibley et al., 2015)

Balance/postural stability - “The ability to control the centre of mass in relationship to the base of support” (Shumway-Cook & Woollacott 2007).

Base of support (BoS) - the area of the body that is in contact with the support surface (typically the ground).

Centre of gravity (CoG) is the vertical projection of COM onto the ground.

Centre of mass (CoM) - “a point that is the centre of the total body mass, which is determined by finding the weighted average of the COM of each body segment” (Shumway Cook & Woollacott 2007).

Centre of pressure (CoP) is the point location of the vertical ground reaction force vector. It represents weighted averages of pressures distributed over the surface of the area when feet are in contact with the ground. To keep the CoM within the base of support requires the CoP to continuously move around the CoM (Shumway-Cook & Woollacott 2007).

Cognitive Influences – Ability to maintain stability while responding to commands during the task or attend to additional tasks (eg, dual-tasking) (Sibley et al., 2015)

Dance Dance Revolution (DDR) is an interactive dance based game created by Konami. DDR aims to get people moving on a dance mat to different music, using forward and backward and side to side arrows.

Dynamic Stability – Ability to exert ongoing control of centre of mass when the base of support is changing (eg, during gait and postural transitions) (Sibley et al., 2015)

Exergaming - a combination of exercise and computer gaming, for instance, Nintendo Wii™ or the XBOX Kinect™ as examples of commercial products.

Flow - a state in which an individual can become totally immersed within an activity; in the thesis, flow state will be assessed using a flow state scale questionnaire which comprise 36 items.

Functional Stability Limits – Ability to move the centre of mass as far as possible in the anteroposterior or mediolateral directions within the base of support (Sibley et al., 2015).

Mira Rehab™ - A rehabilitation exergame that is used with older adults and individuals with clinical conditions. Mira™ utilises an Xbox Kinect™ camera currently and the exergame is downloaded and played on a digital platform.

Nintendo Wii™ - Released in 2006, the Wii is a popular exergame that uses a hand-held Wii remote to control the Avatar characters by pointing the remote at the screen.

Postural control - involves controlling the body's position in space for enabling stability and orientation, and is active in all positions (supine, sitting and standing).

Postural sway - Humans sway invariably to maintain balance using small forward and backward (anterior-posterior) and side-to-side (medial-lateral) motions, the magnitude or velocity of which is a measure of balance.

Reactive Postural Control – Ability to recover stability after an external perturbation to bring the centre of mass within the base of support through corrective movements (ankle, hip and stepping strategies) (Sibley et al., 2015)

Sensory Integration – Ability to reweight sensory information (vision, vestibular, somatosensory)

Static Stability – Ability to maintain position of the centre of mass in unsupported stance when the base of support does not change (may include wide stance, narrow, 1-legged stance, tandem-any standing condition) (Sibley et al., 2015)

Underlying motor systems – Strength and Coordination (Sibley et al., 2015)

Unified Theory of Acceptance and Use of Technology (UTAUT) - a questionnaire designed to assess people's behavioural intention for future use.

Verticality – Ability to orient appropriately with respect to gravity (eg, evaluation of lean) (Sibley et al., 2015)

XBOX Kinect™ - an interactive exergame which captures body movements in real time without the need to use worn or handheld controllers; the person's body acts as the controller using gesture recognition.

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1.0 INTRODUCTION

1.1 Overview

This chapter provides an explanation of the rationale for the research project, which begins by describing the epidemiology of falls and the prevalence in the older population, and how an impairment in the postural control system produces a risk factor for falls. The chapter then goes on to describe how exercise with a challenging balance component is an optimal approach to prevent falls and how exergaming (exercise gaming) was introduced as an alternate modality. Furthermore, the chapter explores the reasons behind why exergaming may be beneficial as a means to improve postural control for older adults, how a research framework may assist in tailoring exergaming interventions to do so and concludes with an outline of the organisation of the thesis.

1.2 Background

1.2.1 Falls

Life expectancy in western Europe has increased remarkably in the 20th century by 30 years (Christensen et al., 2009). The United Kingdom's (UK) population is projected to reach 74 million by 2039 (Table 1.0).

Table 1.0 - Age distribution of the UK population, 1976 to 2046 (projected)

	0 to 15 years (%)	16 to 64 years (%)	Aged 65 and over (%)	UK population
1976	24.5	61.2	14.2	56,216,121
1986	20.5	64.1	15.4	56,683,835
1996	20.7	63.5	15.9	58,164,374
2006	19.2	64.9	15.9	60,827,067
2016	18.9	63.1	18.0	65,648,054
2026	18.8	60.7	20.5	69,843,515
2036	18.0	58.2	23.9	73,360,907
2046	17.7	57.7	24.7	76,342,235

Source: Office for National Statistics

Notes: 1. Population estimates data are used for 1996 to 2016, while 2014-based population projections are used for 2026 and 2036. UK = United Kingdom.

As a result of the ageing population, the old age dependency ratio (OADR) is increasing from 285 older adults over the age of 65 years for every 1000 people aged 16 to 64 to between 200 and 600 by 2036 (Office for National Statistics, 2017). As we age, the physiological systems of the human body begin to slowly deteriorate (Young, 1997). This phenomenon has been delayed with thanks to improved healthcare services, changes in diet and lifestyle choices (Davis et al., 2010). Yet, with the population balance (OADR) changing, with it comes stresses and strains on community services such as healthcare services (Timmins, 2010). Following retirement and heading into old age, older adults over the age of 65 years are at a higher risk of falling and depend more on healthcare services. The National Institute for Health and Care Excellence (NICE) clinical guideline (CG161) also includes older adults from the age of 50 to 64 given the severity of their risk of falling, judged by a clinician for underlying conditions (National Institute for Health and Care Excellence, 2013). The Public Health Outcomes Framework (PHOF) reported that in 2013 to 2014 in England, there were 255,000 emergency hospital admissions relating to falls, with around 173,000 (68%) of these patients aged 80 and over (Public Health England, 2018). According to the Chartered Society of Physiotherapy (CSP) Fall Prevention Economic Model (FPEM), published in 2014 and later revised in 2016, roughly 98,000 falls are classed as mild (no treatment needed), 102,000 are classed as moderate (referral to a GP, but otherwise no treatment needed) and 37,000 falls are classed as major (any hospital admission) which can result in an individual average cost of £5000 per fall. Across the UK, this costs the National Health Service (NHS) £1.5 billion annually. This equates to 30% percent of community-dwelling older adults over the age of 65 years falling each year and this number increases to 50% of older adults heading into their 8th decade (Chartered Society of Physiotherapy, 2016). The FPEM shows a return on investment of over £4 when £1 is invested in physiotherapy for falls prevention (Chartered Society of Physiotherapy, 2018).

A World Health Organisation (WHO) factsheet has defined a fall as “an event which results in a person coming to rest inadvertently on the ground or floor or other lower level. Fall-related injuries may be fatal or non-fatal, though most are non-fatal” (World Health Organisation, 2018). Often when questioned about falls, older adults tend to either under or over exaggerate a situation pertaining to a fall. In the Visually Impaired Older people’s Exercise programme for falls prevention (VIOLET) feasibility study, older adults were questioned on falls, whereby most participants stated having fell, however, not directly to the ground and had actually experienced a “near miss”. These types of falls can be attributed to slipping or tripping which results in catching the fall prior to lower level contact, which still contribute to an increased fear of falling (Adams et al., 2018). Physiotherapy can play a role in reducing the severity of a fall from major classification to a minor classification (Chartered Society of Physiotherapy, 2018). Research has begun to classify falls in relation to their context. Mactier et al. (2015) developed a classification based on falls related activity: 1) advanced, 2) combined and 3) transitional. Mactier et al. (2015) explored the relationship between ambulatory activity and falls in people with Parkinson's Disease (PD) and compared an association for falls frequency and falls context. They found no relationship between PD fallers and PD non-fallers based on fall frequency alone. When applying the context classification (based on pre-fall event) they were able to distinguish between the two in total time spent walking and disease severity which demonstrated greater discrimination between phenotypically different fallers (Mactier et al., 2015). The Fall-Related Activity Classification has since demonstrated excellent inter-rater reliability (23 raters) between physiotherapists, physicians and non-medical researchers κ = 0.807 (95% CI 0.732 to 0.870) (Ross et al., 2017).

Consequences of falls can result in physical and psychological harm. Physical harm from falls can differ depending on the force generated from the interaction with the environment including the nature of the surface in which the body lands and any objects that the body touches on the way down to a lower surface. Falls on level ground often have less disastrous effects than those occurring from a height, such as from the top of a flight of stairs. For older adults willing to go out in riskier conditions such as snow and ice on the surfaces of the pavements, environmental factors such as the time of year has also previously shown to have small consequences on falls (Nachreiner et al., 2007). Variation between rural and urban hospital admissions from falls have previously received attention and shown to vary from country to country (Aoyagi et al., 1998, Ringsberg et al., 1998, Reyes-Ortiz et al., 2005). Falls can result in injury, lacerations, fractures and worst-case scenario, death (Tinetti et al., 1988). The pain, immobilisation and inability to go about typical daily activities can cause distress and can leave lasting psychological harm or concernment for other areas of life such as work, keeping up with financial payments and can be taxing on relationships. This in turn can lead to more psychological ailments such as depression, anxiety and having a fear of the event occurring in another instance, known as fear of falling.

The multifactorial risk factors for falls can be categorised demographically, psychosocially, medically, physically and environmentally. Several preventive strategies and guidelines have been compiled to address these factors such as the NICE guidelines that provides recommendations for the assessment and prevention of falls in older people (National Institute for Health and Care Excellence, 2013). Causes for falls have been reported to be accidental or environmental (30-50%), however, can be attributed to a combination of environmental hazards and susceptibility to hazards from accumulated effects of age and disease. Problems in older adult's gait when negotiating obstacles remains the second largest cause for falls (10-25%). When negotiating fixed obstacles, older adults adjust step length and step time for the obstacle one or two steps in advance of their younger counterparts and display shorter step lengths, slower gait speed and smaller obstacle-heel distance when crossing an obstacle (Caetano et al., 2016). In addition to fixed obstacle negotiation, older adults have longer avoidance reaction times, larger toe clearances and lower obstacle avoidance success rates compared with young adults which can be attributed to decline in the biomechanical components such as joint mobility in the lower limbs, appropriate timing of muscle action; appropriate intensity of muscle action; and normal sensory input, including vision, proprioception and vestibular system (Lord and Dayhew, 2001, Feder et al., 2000). Problems in older adult gait can occur from age-related changes in balance, which can occur from specific dysfunctions of the nervous, muscular, skeletal, circulatory and respiratory systems (Rubenstein, 2006). Other causes for fall are dizziness, orthostatic hypotension, drop attacks, syncope and disorders of the central nervous system, cognitive deficits, poor vision, drug side-effects, alcohol intake, anaemia, hypothyroidism, unstable joints, foot problems, severe osteoporosis with spontaneous fracture and acute illness (Rubenstein, 2006). The ability to identify the specific risk factor for falls can be problematic due to the multifactorial risks predisposing to falls, however, impaired postural control is one of the known risk factor for falls.

1.2.2 Postural Control

Postural control is the ability to maintain, achieve, or restore a state of balance during any posture or activity. It is a complex motor skill whereby multiple sensorimotor process interact to control the body's position in space for dual purposes of stability and orientation and remains active when standing, sitting or lying down. The ability to maintain alignment between the body segments, the environment in which the task is conducted and the body is referred to as postural orientation (Horak and Macpherson, 1996). During postural orientation, the body is actively controlling alignment and tone with respect to visual environment, internal references, gravity and the support surface. The ability to maintain the centre of mass (CoM) within the base of support (BoS) is known as postural stability (Shumway-Cook and Woollacott, 1995).

During activities of daily living (ADLs), varying demands of postural task, environmental constraints and adaptations from an individual can affect postural control and there are six physiological domains that contribute to the maintenance of postural control and make up the Systems Framework for Postural Control (SFPC) (Horak, 2006) (Figure 1.0). *Sensory Integration* involves the reweighting of sensory information independent sensory sources: somatosensory, vestibular and visual inputs, also known as spatial orientation and are all controlled by the central nervous system (CNS). Sensory information feedback changes continuously given the environment, task or individual maintaining equilibrium. For healthy adults, the somatosensory system is responsible for 70% of the information required to maintain postural control, with the vestibular system accounting for 20% and the visual system responsible for 10% of the postural control mechanisms when standing on a flat, stationary surface in a controlled environment (Peterka, 2002). Sensory reweighing is the ability to rely and choose on different sensory inputs, depending on the condition of the postural stability activity. When standing on an unstable surface (foam) the CNS increases the sensory inputs from the vestibular and visual systems and reduces the information from the surface somatosensory inputs (Peterka, 2002). Therefore, if any decrement in one or more of the sensory systems is damaged or impaired it will result in altered postural stability. Given that the sensory inputs related to various environmental conditions are constantly changing, the ability to adjust instantly to a change in sensory information is central to the reduction of fall risk in older adults (Peterka and Loughlin, 2004).

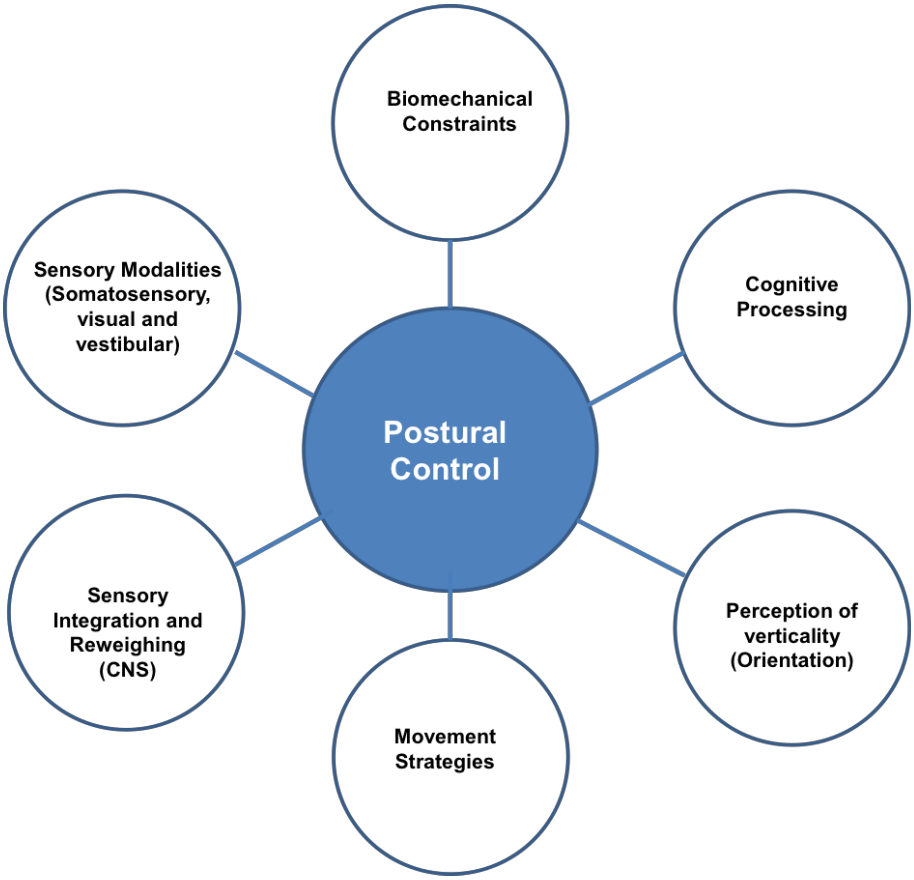

Figure 1.0 - The six physiological domains that contribute to the maintenance of postural control. The Systems Framework for Postural Control (SFPC) (Horak, 2006)

Biomechanical constraints refers to the size and quality of the BoS and the feet are considered the most important constraint on balance (Tinetti et al., 1988, Horak, 2006). There are several factors that limit balance at the feet, which can be attributed to limitations in size, range, strength and control (Tinetti et al., 1988). The second biomechanical constraint is the relation of maintaining equilibrium between the CoM and the BoS. The Limits of stability (LoS) is the area and range in which an individual can move their CoM without moving the BoS and is represented in a cone shaped diagram in Figure 1.1.

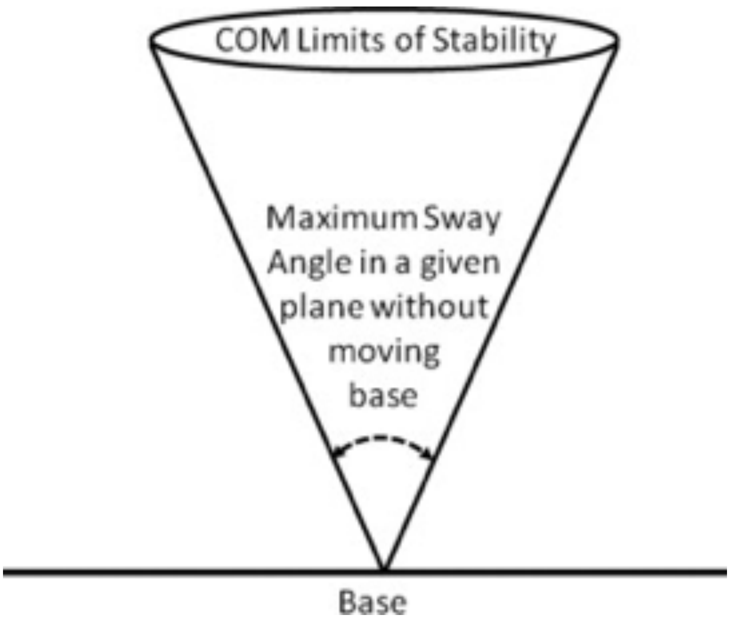

Figure 1.1 - Limits of stability cone shape representation

The LoS changes with respect to the environment and task (Pai et al., 2000). The LoS in older adults prone to falls is often represented by a much narrower cone or have central neural representations of the cone distorted, which can affect the movement strategy to maintain equilibrium and often result in a fall (Horak, 2006) (Figure 1.2).

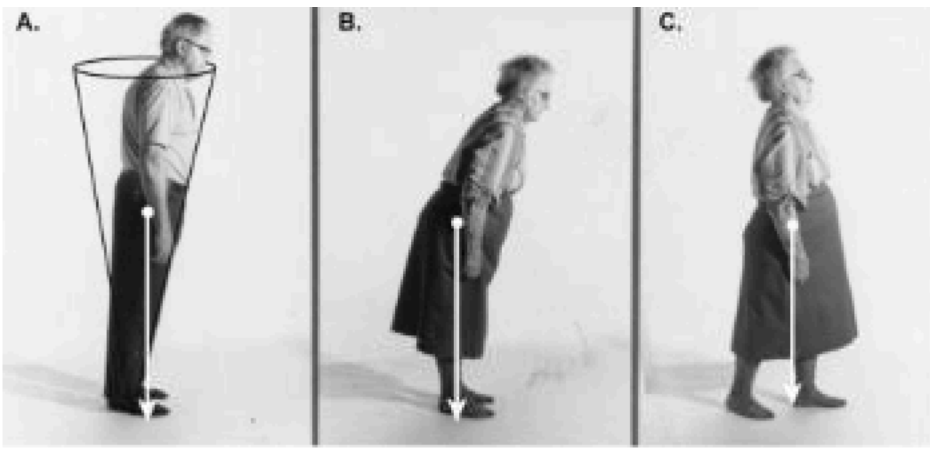

Figure 1.2 - Representation of normal and abnormal limits of stability. Taken from Horak (2006) (A) Healthy male leaning his body’s centre of mass (CoM) (white dot) towards his forward limits of stability, represented as the area of a cone. (B) Female with multisensory deficits attempts to lean forward without moving her body CoM

forward. (C) Woman with multisensory deficits attempts to lean backwards but immediately takes a step to increase her base of support. The projection of the body CoM over the base of foot support is indicated schematically with a white arrow.

Movement strategies are actions that occur at hip, ankle and through stepping strategies to maintain equilibrium (Nashner and McCollum, 1985, Horak, 1987). When experiencing small perturbations, the ankle strategy is employed through producing torque at the ankle and restoring the CoM to equilibrium. However when the BoS is narrowed, such as when only one foot is in contact with the ground, or during tandem stance (one foot directly in front of the other), the hip strategy is employed and undertakes vast movements to control the CoM and restore equilibrium (Horak and Nashner, 1986). Stepping strategies are the last port of call when ankle and hip strategies are not sufficient to maintain control and relies on moving the BoS to bring the CoM back within equilibrium. A more necessary strategy for older adults suffering muscular dystrophy and are prone to falls (Horlings et al., 2008).

Postural control information is integrated within the CNS in order to coordinate and execute an appropriate motor response. *Cognitive processing* is needed during postural control tasks as well as other attentional demanding tasks and as the complexity of the postural control task increases or when attentional demand is divided between two tasks, cognitive processing increases and reaction time decreases (Woollacott, 2000). The sharing of cognitive resources between postural control and other cognitive processing results in the performance of the postural task being affected by a second concurrent cognitive task, also known “dual-tasking”. Age and balance capability are two factors that may demand greater attentional requirements (Woollacott and Shumway-Cook, 2002). Older adults or individuals with neurological disrepair have shown greater centre of pressure (CoP) displacements when concurrently performing a complex secondary task. This can result in insufficient maintenance of postural control and ultimately end in a fall (Huxhold et al., 2006).

Orientation in space is the ability to orient the body parts in respect to gravity, visual surround, the support surface and internal references is necessary to maintaining equilibrium (Horak, 2006). Variations in surface, gravity and the environment in which the task takes place requires the human body to orient appropriately during postural tasks. Perturbation platforms can subject an individual to changing gradients of support surfaces to assess the level of dynamic postural stability with respect to gravitational forces. Visual inputs provide vertical references within the environment in the form of vertical alignment such as a door, the edges of curtains, walls and windows in the home that feedback to maintain postural control. For older adult fallers, the ability to maintain verticality could become compromised with vision impairment, whereby vertical references are tainted and could impact both static and dynamic postural stability.

1.2.3 Exercise and balance training

Exercise, with a strong challenge to balance abilities (postural control), is supported by sufficient evidence and recommended in the NICE guideline CG161 that details that appropriately designed intervention programmes can reduce the rate and risk of falls at the population level for older adult fallers (Sherrington et al., 2011, Gillespie et al., 2012, El-Khoury et al., 2013). Various designs of home and group based programmes have shown to reduce falls such as standing and sitting targeted exercises, Tai Chi, yoga and other modalities (Gillespie et al., 2012). Home-based exercise programmes have also been designed for use with older adults and especially those who are apprehensive to attend a group-based class (Campbell and

Robertson, 2003). The Otago Exercise Programme (OEP) has reduced rates of falls and injurious falls by up to 35% (Sherrington et al., 2011). This method to prevent falls has shown to be cost-effective when administered in single and multi-centred randomised controlled trials (RCT) in New Zealand whereby falls were reduced by 46% and 30%, respectfully (Robertson et al., 2001a, Robertson et al., 2001b). The eight recommendations proposed by Sherrington et al (2011) suggest that exercise must provide a moderate or high challenge to balance (reducing BoS, moving the CoM and reducing the need for upper limb support with exercise) (1), exercise must be of a sufficient dose to have an effect (2 hours per week for 6 months, totalling 50 hours) (2), incorporate ongoing exercise as a necessity (3), exercise should be targeted at the general community as well as those at high risk for falls (4), exercise may be undertaken in a group or home-based setting (5), walking training may be included in addition to balance training but high risk individuals should not be prescribed brisk walking programs (6), strength training may be included in addition to balance training (7) and exercise providers should make referrals for other risk factors to be addressed (8). Full adherence to an exercise programme designed to reduce falls has shown to outperform partial adherence and non-adherence on clinical measures of balance and mobility (Shumway-Cook et al., 1997). However, exercise adherence following discharge from a physical therapy programme is poor among older adults in that barriers, not motivators, appear to predict adherence (Forkan et al., 2006). Barriers to participation and adherence still exist in that although community-based fall prevention programmes have found large relative effects at preventing falls, home-based exercise adherence to balance-training remains low (Clemson et al., 2004, Campbell and Robertson, 2007, Gillespie et al., 2012). Research has demonstrated the potential of specific and general exercises to improve postural control, however, the amount of people regularly taking part in balance based training is low owing to the tedious nature of the training which has previously shown to impact adherence and intrinsic motivation levels (Maclean et al., 2000, Fitzgerald et al., 2010, Nilsson et al., 2012, Lohse et al., 2013).

1.2.4 Exergames for exercise and rehabilitation

Exergames were introduced from the gaming sector as an alternate mode of exercise to motivate the general population to improve health related outcomes such as obesity and sedentary behaviour. “Exergames” or “Exergaming” is a branch of interactive computer gaming that stemmed out of the virtual reality community which dates back to the 1970’s. Myron Krueger coined the term ‘artificial reality’ to describe ‘interactive immersive environments’ (Krueger et al., 1985). Exergames or “exercise games” are games played which incorporate physical exercise whereby the movements conducted drive the gameplay. Exergame devices are controlled using broad variety of sensor systems whereby the most widely used sensors in exergame consoles and apparatus are accelerometers, gyroscopes, infrared (IR) and Red, Green and Blue (RGB) optical sensors and pressure sensors (van Diest et al., 2013). Commercially available consoles such as Dance Dance Revolution™, Sony PlayStation Eye Toy™, Nintendo Wii™ and more recently the Xbox Kinect™ are an affordable modality to exercise for health. Exergaming is an innovation that offers an alternative option for users less inclined to attend group-based physical activity classes, is available and can be used in various community settings. The prospect of exergames to provide an alternative option to exercise in the community, provide an additional choice for exercise sessions and enhance the accessibility of exercise through the medium of technology shows to be promising with the ability to monitor progression through various forms of feedback to the user during and after gameplay. A meta-analysis of energy expenditure (EE) during exergames has shown to significantly increase heart rate (HR), oxygen uptake (VO2), and EE from rest for all age groups. The results indicated similar effect sizes to traditional low to moderate physical activities (Peng et al., 2011). Exergames have also been deployed to counter the globally increasing child obesity rates by reducing body mass index (BMI) (Ameryoun et al., 2018) and energy intake (EI) following a period of exergaming compared to seated video gaming (Allsop et al., 2016). Exergames have since caught the attention of educators through the large number of exergames that can be incorporated into a physical education curriculum for children and youth (Vaghetti et al., 2018, Staiano and Calvert, 2011).

Exergames have been promoted for use with older adults to increase physical activity levels, combat the decline in mobility of the upper and lower extremities. A recent systematic review has categorised exergame applications for older adults physical activity into 9 categories and 19 themes into a taxonomy to direct exergaming applications for older adults (Figure 1.3) (Kappen et al., 2018). Balance training formed the largest theme of 28.6% of articles in the review followed by physical activity, wellness and rehabilitation (14.3% each), physical training (12.2%) and cognitive training (8.2%) or a combination of both (4.1%). A recent meta-analysis suggests that physical activity programmes with strong cognitive tasks offer superior cognitive benefits than those with just physical activity and may alleviate cognitive impairment through altering the plastic properties of the brain (Gheysen et al., 2018).

1.2.5 Exergames and postural control

Exergames for postural control training offers the opportunity to not only promote physical activity for older adults but to incorporate both a strong balance and cognitive challenge during gameplay concurrently (Anderson-Hanley et al., 2012). The most popular gaming console used for balance training over the last decade was Dance, Dance Revolution™ for stepping exergames, the Nintendo Wii™ and balance pressure board console for weight shifting exergames and more recently the Xbox Kinect™ sensor which allows for a variety of movements (van Diest et al., 2013). A randomised controlled trial (RCT) conducted by Barry et al. (2016) assessed the effects of exergaming using XBOX Kinect™ versus traditional gym-based exercise with no virtual stimuli (TGB) on postural control, technology acceptance, flow experience and exercise intensity, in young healthy adults. They found that postural control (CoP medio-lateral) could be improved by using the Kinect™ as well as higher levels of technology acceptance and flow in the exergaming group (Barry et al., 2016). A RCT by Robinson et al. (2015) examined the effects of exergaming compared to a standard balance training group on postural sway, gait, technology acceptance and flow experience in people with Multiple Sclerosis (MS) and found that postural sway improved for participants in both the Wii Fit™ and traditional balance training groups. Furthermore, participants in the exergame group experienced higher states of flow during training attributed to higher awareness, higher attainable focus, clear immediate feedback and more autonomy during task involvement (Robinson et al., 2015). Exergames have been previously employed to train balance or postural control in older healthy adults and adults with impaired postural control. A pilot RCT comparing three modalities of postural control training for 40 older adults (Tai Chi, standard balance training and Nintendo Wii™ and Wii Fit™) found no significant differences between the groups using a vast range of outcome measures including functional and mobility assessment, force plate CoP, dynamic posturography and self-report questionnaires (Pluchino et al., 2012). Ray et al. (2012) analysed the impact of a traditional group fitness class and a Wii™ fitness exercise program on 87 community-dwelling seniors' ability to maintain postural control with an environmental distracter (sensory organisation test). Both interventions were successful at improving postural control (Ray et al., 2012). Bateni et al. (2012) compared traditional balance training modalities against Wii™ based exergames on 19 older adults and found improvements in the Berg Balance Scale and the Bubble Test in that exergames do improve balance (Bateni, 2012). Exergames for physical activity, and more so for training postural control, is a young area of research. It is important to understand the extent to which exergames compare to traditional balance training therapies available in the community. To date, there appears to be no theoretical basis for investigating changes in mechanisms of postural control in exergaming interventions for community-dwelling older adults. The literature also suggests that there is no systematic approach to designing exergaming interventions for older adults who may be prone to falling in the community. This suggests that there is still design and development work necessary to optimise exergaming interventions for older adults living in the community, where complex factors must be considered to implement interventions successfully. The Medical Research Council (MRC) framework for complex interventions may add value to overcoming the development and evaluation difficulties of exergaming interventions and aid the recognition and adoption of appropriate methods for use in a future definitive trial. The interventions aimed at improving postural control to aid fall prevention for older adults involves a number of interacting components within the experimental and control groups, certain behaviours of those delivering or receiving the intervention, variability of outcomes and a degree of tailoring of the intervention. Researchers that design and development of exergaming interventions must consider these factors during the planning of behaviour change, which can ultimately provide evidence that they are effective in everyday practice. The framework characterises the process of development and evaluation in four phases: 1) development, 2) feasibility and piloting, 3) evaluation and 4) implementation (Craig et al., 2008). This thesis will implement phase 1 and 2 of this framework. It will begin by developing appropriate methods with a coherent theoretical basis for an exergaming intervention followed by phase 2, to perform and assess the feasibility of implementing an exergaming intervention in the community.

Following the development work of the MRC, initially it is important to understand the effectiveness of the existing evidence pertaining to exergaming interventions. This will be evaluated in a systematic manner through conducting a systematic review. As part of the systematic review process it is important to understand how exergames compare to traditional therapies already available in the community for older adults and the quality of the current evidence available. Information from outcomes assessed, movements trained and the general characteristics of exergaming interventions will provide a starting point for the changes necessary to be made from a study design stand point. To form additional structure to the systematic review process, a theoretical framework of postural control will be adopted to define the specific outcomes to be included, which have been well established for postural control (Horak, 2006, Sibley et al., 2015).

As part of the review of existing evidence, it would be of use to evaluate what outcomes are assessed in exergaming interventions and to understand the use of outcome measures employed to measure the various components of postural control. Previous research has summarised the effects of exergames in comparison with traditional balance training programmes with a focus on outcome measures employed but not in a systematic manner and not in conjunction with postural control theory (van Diest et al., 2013). In addition to the outcomes and measures of interest, little is known on the movements trained during exergaming interventions, other than those briefly described in journal articles. There is a gap in the understanding how the movements in exergames train postural control, with respect to postural control theory, and if they correlate with the measures employed for assessment. A review of the evidence may provide highlight areas in the research that require attention for the use of exergames to improve postural control, with respect to postural control theory. In this thesis, older adults beginning to fall, will be used to explore the feasibility of implementing exergaming in the community. The review of the evidence will focus on healthy older adults and those prone to falls, but the development of the intervention will include only older adults beginning to fall. This approach is supported by the premise that intervention development must be suitable for the target population and understanding differences between healthy older adults and older adults prone to falls may provide insight into how to target the intervention more so for those more prone to falls.

Postural control was chosen as the primary outcome measure due to it being a significant risk factor for falls, and is a fundamental aspect of activities of daily living (ADL) for older adults (Tinetti and Williams, 1998). Exergaming is still a relatively new concept in postural control research and older adults that are beginning to fall are an appropriate baseline measure prior to implementing exergames to train postural control with more clinical populations. Older adults aged 60-64 years are not categorically high risk older adults, yet the implementation of fall prevention strategies tends to focus on individuals aged 65 years and above. Previous research by Hobbs et al. (2013) found that behavioural interventions in adults aged 55 to 70 years led to long term improvements in physical activity at 12 months which have substantial health benefits in reducing the risk of age-related illnesses (Hobbs et al., 2013). This may also apply to reducing the risk of falls through interventions focused on improving postural control outcomes. To intervene at the age of 60 years provides the opportunity to minimise the potential threat to physical activity levels which ultimately will have an effect on balance and mobility, which in turn can help to reduce the risk of falls.

To summarise, this thesis aimed to develop and implement a feasibility study of exergaming to improve postural control in community dwelling older adults using the MRC framework for complex interventions and the SFPC to ensure all domains of postural control that are linked to underlying physiological and biomechanical systems are included. This thesis aimed to apply phase 1 of the MRC framework 1) by systematically reviewing the evidence base and perform a meta-analysis of exergaming interventions versus traditional methods to train postural control for community-dwelling older adults to provide insight into the current status of the characteristics of exergaming interventions and highlight which outcomes are assessed and which measures are used, 2) by systematically reviewing the literature to assess the movements trained in exergaming interventions, using a movement rating scale supported by a theoretical framework for postural control to understand what is being trained in exergaming interventions and 3) by exploring the differences in behavioural intention towards exergames among adults in general to understand the differences in perceptions of exergames among different age groups and how that may impact the intention to use exergames for older adult fallers. This thesis then aimed to apply phase 2 of the MRC framework to 4) collate the evidence from phase 1 and implement a pilot intervention of exergaming, compared to traditional balance training and no balance training as means to improve postural control for older adult fallers, and 5) to explore perceptions of the target population that received the intervention to provide feedback on the intervention and the intention to use exergames to train postural control.

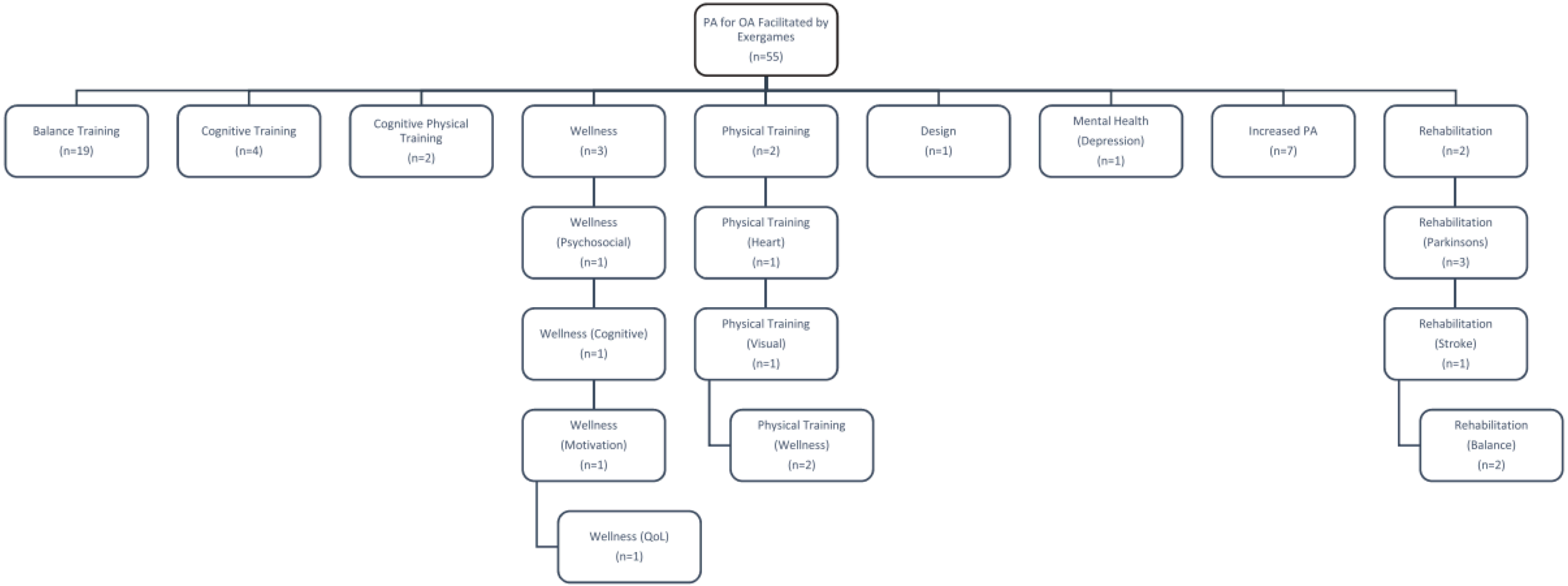

Figure 1.3 - A taxonomy of 19 exergame themes for use in physical activity with older adults (Kappen et al., 2018)

1.3 Thesis aims and layout

It is the intention of this thesis to follow the MRC framework to develop a feasibility study and pilot an exergaming intervention to assess the feasibility of exergaming to improve postural control for older adults living in the community.

1.3.1 Research question

Is exergaming a feasible option to implement in the local community as an intervention to improve postural control for older adult fallers?

1.3.2 Study aims

1) To systematically review the literature and perform a meta-analysis of exergaming interventions versus traditional balance interventions and no intervention for community-dwelling older adults, in conjunction with a framework for postural control.
2) To systematically review the literature for movements trained in older adults during exergaming interventions that are associated with a framework for postural control.
3) To investigate the usability and acceptance (behavioural intention) of exergaming, and explore any initial age-related differences in perceptions of exergaming to train balance.
4) To investigate the feasibility of delivering a low-cost, pilot intervention of exergaming versus traditional balance training and no intervention in the community for older adult fallers.
5) To explore the perceptions of the target population to provide feedback on the intervention and the intention to use exergames to train postural control.

1.4 Thesis structure

1.4.1 Systematic Review 1: A systematic review and meta-analysis of exergaming versus traditional balance training or no intervention on postural control outcomes and measures in older adults living in the community.

Aims:

To systematically and meta-analytically explore if exergaming is as effective as traditional balance training methods at improving postural control outcomes, drawn from the SFPC, in older adults living in the community.

A subsidiary aim is to categorise the meta-analysis by the type of outcome measure used (primary, secondary and tertiary) to explore any differences in intervention effects.

1.4.2 Systematic Review 2: Movements of older adults during exergaming interventions that are associated with the SFPC.

Aims:

To systematically explore movement characteristics that train postural control during exergaming interventions in conjunction with the SFPC. To systematically address which movements are being trained and which system set-up best meets the components of the SFPC, if any. This approach may inform the design of exergames in the future and provide evidence to contribute to the design of a pilot intervention.

1.4.3 Study 1: An exploration of usability and acceptance (behavioural intention) of exergames via focus groups among healthy adults of various ages, including a trial of a tailored exergame (Mira™) for the older cohort.

Aims:

To investigate the usability and acceptance of exergaming to train postural control and to explore any age-related differences or similarities in the perceptions of adults on using exergames to train balance.

1.4.4 Study 2: Implementation of a pilot intervention to assess the feasibility of using a tailored exergame to improve postural control in community-dwelling older adult fallers.

Aims:

To implement the evidence from phase 1 of the MRC framework into phase 2; a pilot intervention to assess if exergaming, using a tailored exergame, is feasible for community-dwelling older adult fallers. The intervention set out specific progression criteria and compared recruitment rates, adherence and completion rates of training and assessments, and implemented the use of a novel outcome measure as the potential primary measure to assess postural control. Three groups were included in the pilot intervention: an exergaming group (Mira™, Mira Rehab Ltd), a local fall prevention group (Staying Steady) and a no intervention control group.

1.4.5 Study 3: To explore the perceptions of community-dwelling older adult fallers to provide feedback on a pilot intervention and provide insight on the intention to use a tailored exergame to train postural control.

To explore qualitative reports from semi-structured interviews to gain insight into the acceptability and usability of a tailored exergame intervention compared to a traditional balance training intervention. It is also the aim to explore perceptions on immersion of participants during training sessions, the training programs potential impact on older adult’s levels of fatigue, depression, fear of falling and balance confidence. The evidence from which will contribute to recommendations for a future more definitive trial.

2.0 SYSTEMATIC REVIEW

2.1 Introduction

The aim of this chapter is to systematically assess the existing evidence and provide an overview of the characteristics of exergaming interventions aimed at improving postural control outcomes for older adults. This chapter will assess the outcomes that are currently used in exergaming interventions, in conjunction with the Systems Framework for Postural Control to give a comprehensive overview of which areas of postural control are or are not being assessed in line with postural control theory. A subsidiary aim is to categorize the type of outcome measure used to explore whether or not the way in which postural control is measured has a subsequent effect on the intervention. By understanding and documenting current characteristics of exergaming interventions, the outcomes assessed and their associated measures, this systematic review will contribute evidence for the effectiveness of exergames to the development of a pilot intervention of exergaming for older adult fallers.

2.2 A systematic review and meta-analysis of exergaming versus traditional balance training or no intervention on postural control outcomes and measures in older adults living in the community.

2.2.1 Introduction

2.2.1.1 Background

As previously discussed in Chapter 1 section 1.2.1, falls are associated with ageing and disease, with one third of people aged 65 years and older falling at least once per year (Spaniolas et al., 2010, Gill et al., 2013). In older individuals, a strong predictor of falls is impaired postural control among other factors (Lajoie, 2004, Delbaere et al., 2010). Postural control is the ability to maintain, achieve, or restore a state of balance during any posture or activity (Pollock et al., 2000). Correct postural control requires accurately timed vestibular, visual, proprioceptive and somatosensory inputs for adaptive strategies for orientation and balance (Laughton et al., 2003). Domains of postural control have been broken down into 9 categories to make up the Systems Framework for Postural Control (SFPC) (Horak, 2006, Sibley et al., 2015). The SFPC assists in identifying deficits of postural control and insists on the individual assessment of each component in order to guide rehabilitation programmes. Participation in balance-based training is low due to the tedious and monotonous nature of the training (van Diest et al., 2013). These therapies are repetitive which reduce attention span and impair the effectiveness of the exercises, particularly the large volume of practice associated with chronic neurological and musculoskeletal conditions (van Diest et al., 2013). A more recent method of postural control training is exergaming (van Diest et al., 2013, Bateni, 2012). Exergames are computer games driven by the user's gross physical movements. Due to portability, they facilitate community deployment whereby older individuals have experienced exergaming as a form of postural control training (Laufer et al., 2014). The Nintendo Wii Fit™ had been the most popular exergaming instrument and results have shown beneficial effects on postural control (Laufer et al., 2014). Other exergaming models include X-Box Kinect™, PlayStation Eyetoy™ and Dance Dance Revolution™. The X-Box Kinect™ was revolutionary at the time of its release due to being the first commercial gaming system that does not require a hand-held controller or external device, more so it requires the use of infra-red technology to track an individual's movements.

Outcome measures used in healthcare often reflect a therapeutic intervention created to treat disease and are used to evaluate the efficacy of the proposed treatment (Haigh et al., 2001). A wide range of therapeutic interventions are delivered within the healthcare sector and outcome measures used tend to reflect the diversity of modalities (Haigh et al., 2001). Comprehensive assessment of postural control is encouraged for identifying impairments in postural control and optimising the design of balance-based training programmes for preventing falls (Horak, 2006). Research has shown the varied use of balance measures in fall prevention interventions prevent the synthetization of the data on a general scale and this has also been evidenced in clinics (Howe et al., 2011). Outcome measures employed for balance evaluation, have been previously categorised as functional assessment (documents balance status and change after intervention), systems assessment (determines the underlying reason for impaired balance control), static posturography (quantify postural sway while a subject remains as still as possible) and dynamic posturography (use of external balance perturbations, changing surface and visual conditions) (Mancini and Horak, 2010).

Functional assessment, such as the Berg Balance Scale (BBS) (Berg, 1992) and the Tinetti Performance Oriented Mobility Assessment (POMA) (Tinetti, 1986), quantify functional balance in an ordinal pattern as the participant performs balance and mobility tasks that represent activities of daily living (ADLs). The Functional Reach Test (FRT) (Duncan et al., 1990) uses distance to quantify limits of stability of the centre of mass. The Single Leg Stance (SLS) (Michikawa et al., 2009) or the Timed Up and Go (TUG) (Podsiadlo and Richardson, 1991) use the time domain to measure the task being performed via a stop watch. These measures provide information about postural control, likelihood of falling and functional capabilities. Interrater reliability has been previously reported excellent for BBS, TUG and FRT and has good intra-rater reliability (Langley and Mackintosh, 2007). The TUG and FRT has previously been compared to the BBS for concurrent validity in a broad adult population with significant correlations between the BBS and the TUG (r = .47, *p* = .04), when pairing the TUG and the FRT together against the BBS (r = .56, *p* = .04), but not for correlations between the FRT and BBS (r = .42, *p* = .06) (Bennie et al., 2003). The TUG, POMA and Dynamic Gait Index (DGI) have previously been compared for floor and ceiling effects, sensitivity to change and responsiveness whereby none of the measures had floor effects, but ceiling effects were observed for all measures, which included individuals with moderate to severe functional limitations whereby the BBS showed the least ceiling effects (Pardasaney et al., 2012). All measures had shown low sensitivity to change whereby individuals with lower baseline scores showed better sensitivity to change than their higher scoring counterparts. This highlights limitation in utilising these measures in community-dwelling older adults (Pardasaney et al., 2012). This also highlights the necessity for more challenging measures for higher functioning community-dwelling older individuals. The TUG has shown to be a sensitive (87%) and specific (87%) measure for identifying community-dwelling adults who are at risk for falls (Shumway-Cook et al., 2000). The use of the BBS as a dichotomous scale to identify individuals at high risk of falling, however, has been argued to be discouraged due to its poor sensitivity for any falls (25%) and multiple falls (45%) (Muir et al., 2008). The Balance Evaluation Systems Test (BESTest) is a tool that was designed to analyse several postural control systems that may contribute to poor functional balance in adults (Horak et al., 2009). The BESTest was designed to target treatments to specific balance deficits. The BESTest includes important aspects of dynamic postural control such as the ability to respond to postural perturbations, to stand on a compliant or inclined surface or to walk while performing a cognitive task, which other balance rating scales such as the BBS fail to incorporate (Franchignoni et al., 2010). These are all important features of postural control when assessing balance disorders (Horak, 2006). The BESTest, a 36 item rating scale, has shown excellent intrarater reliability and interrater reliability (intraclass correlation coefficient=.99) and has been highly correlated with the BBS (Spearman r=.96), PASS (r=.96), CB&M (r=.91) in people with subacute stroke across all levels of functional disability (Chinsongkram et al., 2014), in patients with Parkinson disease (PD), vestibular loss, and peripheral neuropathy (Horak et al., 2009). A downfall of the BESTest is the time taken to administer the scale, which has been observed as a shortcoming and limited its routine use (Franchignoni et al., 2010). For this reason, the Mini-BESTest, a 14 item rating scale, was developed via psychometric (Factor and Rasch) analysis to overcoming the shortcoming of the BESTest (Franchignoni et al., 2010). The Mini-BESTest focuses on dynamic balance, has a shorter time to administer, and has, with one exception, excellent to good reliability (ICC > .90) for individuals with mixed diagnoses (Godi et al., 2013, Padgett et al., 2012), stroke (Tsang et al., 2013) and PD (Leddy et al., 2011). Furthermore, the responsiveness of the Mini-BESTest has been examined for minimally important change and a change of 4 points is necessary in individuals with imbalances (Godi et al., 2013) deeming the measure reliable, valid and responsive for use in clinical settings (Potter and Brandfass, 2015).

Unobtrusive self-report questionnaires such as the Falls Efficacy Scale (FES) (Tinetti et al., 1990), which is a scale that quantifies fear of falling subjectively based on a definition of fear as “low perceived self-efficacy at avoiding falls during essential, non-hazardous activities of daily living”. Individuals scoring higher on the scale as are believed to have a higher fear of falling, representing lower self-efficacy and lower confidence and the FES has showed good test-retest reliability (r= .71) (Tinetti et al., 1990). The Falls Efficacy Scale – International (FES-I), a modified version of the FES was developed to assess both easy and difficult activities and social activities, that is useful for a range of languages and cultural contexts. The FES-I has demonstrated excellent internal and test-retest reliability (Cronbach’s Alpha = .96, ICC = .96). The FES-I has showed slightly better power than the FES items to discriminate differences in concern about falling between groups differentiated by sex, age, occupation, falls in the past year, and falls risk factors (chronic illness, taking multiple or psychoactive medications, dizziness) (Yardley et al., 2005). A shortened version of the FES-I was also developed and validated against the FES-I for practical and clinical purposes. The short FES-I has also shown excellent internal and test-retest reliability (Cronbach's alpha = .92, intra-class coefficient = .83), and correlates well with the FES-I (.97) (Kempen et al., 2007). Patterns in differences with respect to mean scores according to age, sex, falls history, and overall fear of falling are similar for the Short FES-I and the FES-I (Kempen et al., 2007). The FES-I has slightly better power to discriminate between groups differentiated by age, sex, falls history, and fear falling, but differences are small.

The Activities-specific Balance Confidence Scale (ABC) (Powell and Myers, 1995) measures perception of balance confidence, which relates to fear of falling for an individual performing ADLs. The difference being that the ABC was developed to represent a wider spectrum of activity difficulty (potentially more hazardous ADLs) than the FES. Total ABC scores have shown excellent test-retest reliability (r = .92) and internal consistency (Cronbach's alpha = .96). FES and ABC total scores have previously been highly correlated (r = .84), but the ABC has shown to be a greater discriminator of low and high mobility individuals (Powell and Myers, 1995). Logistical regression analysis has previously shown that total ABC and BBS scores has predicted falls with 89% sensitivity and 96% specificity (Lajoie and Gallagher, 2004).

A short version of the ABC scale, the ABC-6, was investigated as a valid and reliable measure for assessing balance confidence and for its discriminatory ability to differentiate balance impairments and falls in older adults (Schepens et al., 2010). Although total scores were lower on the ABC-6, correlates were highly matched ($r = .95$) and the ABC-6 was regarded a valid and reliable measure of balance confidence (ICC .82) in community-dwelling older adults (Schepens et al., 2010) and shows a stronger relationship to falls than the ABC scale (16 item). Both measures have been regarded as useful as part of a screening for balance impairment when correlated.

Force platforms quantify the centre of pressure (COP) excursion in mediolateral (ML) and anteroposterior (AP) direction during quiet stance in varying conditions (van Diest et al., 2013). The COP has previously characterised postural control by evaluating the relative sensitivity of COP based measures to changes in postural steadiness (Prieto et al., 1996) and has been correlated with poor balance and risk of falls (Piirtola and Era, 2006). Older adults have previously demonstrated larger areas of COP excursion on a force platform with eyes open, eyes closed or with visual feedback. They displayed longer movement times, longer path lengths of the participant's centre-of-gravity (COG) to different points within their limits-of-stability, and shorter distances of functional reach when compared with younger adults (Hageman et al., 1995). Miniaturised electronic-based body-worn monitors (BWMs) with inertial sensors (e.g. accelerometers and gyroscopes) have objectively and reliably measured postural sway during quiet stance (Moe-Nilssen and Helbostad, 2002, Whitney et al., 2011, Rine et al., 2013). BWMs have been introduced in clinics as an alternative to evaluating postural control in the hope to eliminate clinician bias, increase sensitivity to mild impairments (ceiling effects) and improve reliability of measures (Lara et al., 2013, Godfrey et al., 2015). They have been tested in clinical populations whereby a subset of sensitive, reliable and valid instrumented postural sway characteristics had been formed (Mancini et al., 2012).

2.2.1.2 Aim

To systematically and meta-analytically explore if exergaming was as effective as traditional balance training methods at improving postural control outcomes, drawn from the SFPC, in older adults living in the community.

A subsidiary aim was to categorise the meta-analysis by the type of outcome measure used (primary, secondary and tertiary) to explore any differences in intervention effects.

2.2.1.3 Objectives

The objectives of this review were:

- To assess the overall quality of exergaming interventions undertaken in the community for older adults
- To determine the effectiveness of an exergaming intervention when compared to a traditional balance training intervention or no intervention
- To explore the effect estimate when grouping outcome measures by method of assessment (primary, secondary and tertiary measure types)

2.2.2 Methods

This systematic review was reported according to the PRISMA guidelines (Moher et al., 2009) (Table 2.0).

2.2.2.1 Search strategy

The systematic review was beyond the stage of data collection and therefore could not be registered with PROSPERO, however, it did receive an official statement pertaining to its satisfaction of the inclusion criteria. Electronic databases (CINAHL, EMBASE, PubMed, Web of Science, SPORTdiscus and Science Direct) were searched for publications from January 2000 to April 2016 for interventions performed in clinical and community based settings. Grey literature was not included in the search. The key search terms were merged with Boolean conjunction (OR/AND) and applied on three search levels. Key Search terms used were: (exergam* OR exer-gam* OR videogam* OR video-gam* OR video-based OR Wii OR Nintendo OR X-box OR Kinect OR play-station OR playstation OR virtua* realit* OR dance dance revolution) AND (sport* OR train* OR exercis* OR intervent* OR balanc* OR strength OR coordina* OR motor control OR postur* OR power OR physical* OR activit* OR health* OR fall* risk OR prevent*) AND (old* OR elder* OR senior*). Three levels of screening were carried out: (1) title, (2) abstract, and (3) full-text. The reference lists of the included articles were also searched. Inclusion/exclusion criteria were agreed upon by the two reviewers (RT & GB).

Table 2.0 - Prisma checklist for systematic review published in Maturitas, 2017

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	i
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	2-4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4

METHODS

Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	6
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	5
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	6
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	4
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	5
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	4

Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	5
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	6
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	6
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	21
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	6, 14
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	6
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	9-10

Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	8
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	17-19
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	17-19
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	8
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	14
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	16-17

Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	20
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	21
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	-

2.2.2.2 Selection criteria (PICOS)

Selection criteria for the systematic review can be found in Table 2.1.

Table 2.1 – Systematic review inclusion and exclusion criteria

	Inclusion	Exclusion
Population	Older Individuals between the age of 60 and 85 years old, no neurologic or orthopaedic condition, community dwelling or independently in retirement centres, without cognitive impairment, able to ambulate independently without assistive devices were included.	Individuals who were outside the age range of 60 - 85 years old. Populations with specific neurological (i.e. stroke, Parkinson’s disease, and multiple sclerosis), metabolic (i.e. diabetes), or musculoskeletal (i.e. rheumatoid arthritis) deficits that might impair postural control were excluded.
Intervention	Intervention group treated with exergaming as balance training only or combined with other forms of training such as strength training were included.	Studies where the intervention group was not treated with exergaming as balance training (i.e. virtual reality treadmill training, biofeedback) was excluded.

Comparison	A comparison group treated with traditional balance training or with no intervention or both were included.	Studies not utilising any comparison groups were excluded.
Outcomes	Outcomes of the Systems Framework for Postural Control (static stability, underlying motor systems, functional stability limits, verticality, reactive postural control, anticipatory postural control, dynamic stability, sensory integration, cognitive influences. Any outcome measures designed to objectively and subjectively assess postural control (functional assessment, laboratory based assessment, self-report assessment).	Balance as a tertiary measure was excluded from the meta-analysis.
Studies	Randomised controlled trials (RCT), controlled trials (CT), two group pre and post comparison studies, whereby primary outcome measures were used to	Studies with fewer than six participants in each intervention group were excluded. Studies in which no inferential statistics were reported were excluded.

assess balance or postural control either/or before, during and after a bout of exergaming were included.	Studies that did not meet the inclusion criteria (e.g. all (non-human) animal research)

2.2.2.3 Data extraction

Quantitative data were extracted by one reviewer (RT) and checked by another (GB). Specific details about the interventions, populations, study methods and outcomes of interest were extracted. Primary methods to assess postural control were categorised based on traditional standing and functional mobility tests categorised into rating scales, distance based measures and timed tasks. Secondary methods were based on self-report measures of balance and fear of falling (self-report questionnaires). Tertiary methods were categorised as any instrumentation that objectively quantified postural control (force platforms, perturbation platforms and accelerometers).

2.2.2.4 Quality assessment

Evidence level of included studies were assessed using the Oxford Centre for Evidence-Based Medicine Levels of Evidence (Oxford, 2016). Of the five levels of evidence, level 1 is deemed to be the highest quality of evidence (Table 2.2). To eliminate unintended bias while assessing the studies, both reviewers collaborated and eliminated any conflicting opinions. Eligibility and quality of studies was assessed using the Physiotherapy Evidence Database Scale (PEDro) and were independently assessed by both reviewers (Table 2.3). Methodological quality was also assessed using the a custom-made tool derived from a previous systematic review (Table 2.4) (Barry et al., 2014).

Table 2.2 - Overview of Oxford Levels of Evidence

Hierarchy	EL Criteria
1	Systematic reviews of randomized trials or n-of-1 trials
2	Randomized trials or observational studies with dramatic effect
3	Nonrandomized controlled cohort or follow-up studies
4	Case-series, case–control studies, or historically controlled studies
5	Mechanism-based reasoning

EL = Evidence Level

Table 2.3 - PEDro Quality Assessment descriptions

Item	Description
1	Specification of eligibility criteria
2	Random allocation of subjects
3	Concealed allocation of subjects
4	Similar groups at baseline
5	Blinding of all subjects
6	Blinding of all therapists
7	Blinding of all assessors
8	Key outcome measures obtained from 85% of subjects
9	Treatment received as allocated or “intention to treat”
10	Between-group statistical comparisons reported for one key outcome

11	Point measures/variability measures provided for one key outcome

Table 2.4 - Adapted version of a quality assessment tool used for quantitative research

Question	Scoring
1. Are the research objectives clearly stated?	1 – Yes, 0.5 – Yes, lacking detail or clarity, 0 – No
2. Is the study design clearly stated? Type of trial, number of arms.	1 – Yes, 0.5 – Yes, lacking detail or clarity, 0 – No
3. Are participant characteristics described in detail? (Mean Age, Male/Female)	1 – Yes, 0.5 – Yes, lacking detail or clarity, 0 – No
4. Are inclusion and exclusion criteria stated? (Health Status, ambulatory ability)	1 – Yes, 0.5 – Yes, lacking detail or clarity, 0 – No
5. Is sample size justified? (Why this number?)	1 – Yes, 0 – No
6. Is randomization of groups explained? (not just stated)	1 – Yes, 0 – No

7. Are the location/settings described? (Clinical Laboratory, community based)	1 – Yes, 0.5 – Yes, lacking detail or clarity, 0 – No
8. Is instrumentation clearly described? (Consoles, Games, Game duration, levels, scoring)	1 – Yes, 0.5 – Yes, lacking detail or clarity, 0 – No
9. Are outcome measures described in detail? (Primary, secondary, tertiary)	1 – Yes, 0.5 – Yes, lacking detail or clarity, 0 – No
10. Is duration and intensity of intervention explained?	1 – Yes, 0.5 – Yes, lacking detail or clarity, 0 – No
11. Are the exergaming and if used, other exercise stated in detail?	1 – Yes, 0.5 – Yes, lacking detail or clarity, 0 – No
12. Is post intervention follow up used? If so, is it described?	1 – Yes, 0.5 – Yes, lacking detail or clarity, 0 – No

In addition to analysing quality at the study level, the Grading of Recommendations Assessment, Development and Evaluation (GRADE) system was used to systematically assess the quality of evidence at the outcome level. The use of GRADE was incorporated into the review beyond the protocol stage. When grading the quality of the evidence by the outcome, the GRADE system guidance proposes to choose outcomes that mostly influence decision making for older adults prone to falling. For this reason, it was decided to GRADE the 9 operational definitions of the SFPC (Horak, 2006, Sibley et al., 2015) as outcomes of postural control for this review. Quality ratings downgraded a starting rating of 'high quality' evidence by one level for serious concerns (or by two levels for very serious concerns) about risk of bias, inconsistency, indirectness, imprecision or publication bias for each outcome of the SFPC. One rater (RT) performed the rating and was checked by another (GB). The outcomes selected for inclusion in the meta-analysis were those with sufficient data. This would lead to a synthesis of the studies by outcome, using the GRADE system, to provide an evidence-based statement about the effectiveness of exergaming (Guyatt et al., 2011).

2.2.2.5 Data analysis

Intervention effects were assessed at the outcome level by grouping studies for meta-analysis for each outcome of the SFPC. Outcomes that provided an insufficient amount of data were excluded from the analysis. As the inclusion criteria for this review included two types of comparisons (traditional balance intervention and no intervention), sub-group analyses were performed for any distinguishing effects. Intervention effects were also assessed at the study level by grouping studies for meta-analysis by the method of assessing postural control (Primary, secondary and tertiary). The difference of the target outcomes and outcome measure between the intervention and the control group including the pooled standard deviations, were calculated for the outcomes according to the SFPC and also by category of outcome measure. Random effects models (Review Manager (Revman), version 5.3, Copenhagen, Denmark) were used and between-group standardised mean differences (SMD) were calculated based on continuous measurement scale (mean ± SD). Hedge's g was used to quantify effect sizes for SMD to account for small sample sizes (n<20). For trials utilising multiple intervention arms and compared an exergaming group with an alternative balance training group (group fitness, standardised balance training program, Tai Chi etc.) and a control group (no exercise), the alternative balance training control group were compared to the exergaming group. Where a secondary active control group was included in the study, the control group most representative of traditional balance training was compared to the exergaming group. If no traditional balance training group was available, the control group not undergoing an intervention compared. If the heterogeneity test revealed a value of $p < 0.1$ or $I2 > 25\%$, then heterogeneity was considered likely. Heterogeneity was deemed moderate at <50% and considerable at >50% (Higgins et al., 2003, Deeks et al., 2008).

2.2.3 Results

2.2.3.1 Search strategy

The database search yielded 809 publications (Figure 2.0). After removing all duplicates (346), 463 publications were abstract screened whereby 435 were excluded leaving 28 publications. After searching reference lists of the 28 included publications, an additional 26 were obtained leaving 54. Of the 54 publications, 42 were excluded with reasons to give the final number of included publications for qualitative synthesis in the review (n = 12). Of the 12 publications, one was excluded from the meta-analysis where insufficient data were reported. Data was acquired from one author (Chow and Mann, 2015) and another failed to respond (Tange et al., 2012). Additionally, the Cochrane Central Register of Controlled Trials revealed no further publications for inclusion is this review.

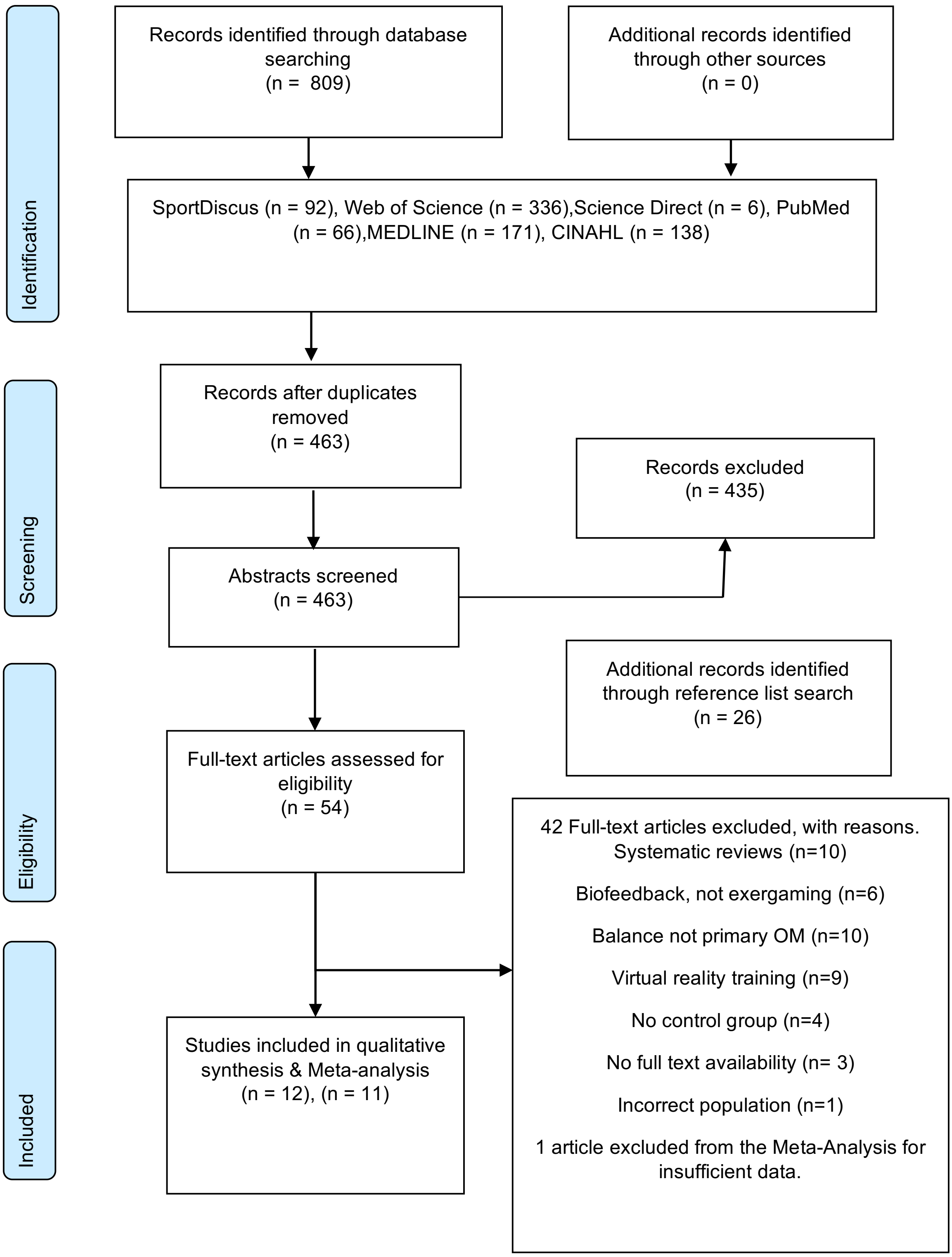

Figure 2.0 – Prisma flow diagram

2.2.3.2 Quality assessment

Nine of the included publications were RCTs, which are considered level 2 evidence, and 3 publications were non-RCT's, which were considered level 3 evidence base (Table 2.5). At the study level, according to the PEDro scale, the mean (SD) methodological quality score of the 12 studies included in the review was 5.17 (1.64). This increased to 5.36 (1.57) for the eleven studies included in the meta-analysis. When excluding the level 3 evidence studies (non-RCT) from the quality assessment the score increased to 5.44 (1.74). A third of the studies reviewed were rated below the mean score which can be attributed to a lack of blinding of the participants, therapists and assessors and a lack of allocation concealment (Table 2.6). There was a seeming lack of explanation for randomisation across trials with only two studies adequately explaining the method for randomising participants. Six trials failed to describe location and no intervention follow up was conducted for any of the trials (Table 2.7 a, b).

Table 2.5 – Results of Evidence Level of included articles

Author and Date	Hiearchy	Evidence Level
Pluchino et al., 2012	RCT (PS)	2
Ray et al., 2012	RCT	2
Toulotte et al., 2012	RCT	2
Merriman et al., 2015	RCT	2
Sato et al., 2015	RCT	2
Whyatt et al., 2015	RCT	2
Lai et al., 2013	RCT	2
Singh et al., 2013	RCT	2

Chow and Mann., 2015	RCT (PS)	2
Nicholson et al., 2015	Non – RCT	3
Park et al., 2015	Non – RCT	3
Tange et al., 2012	Non – RCT (PS)	3

Table 2.6 – Outcomes from PEDro scale quality assessment

Author and Date	Eligibility Criteria	Random Allocation	Concealed allocation	Baseline Comparable	Blind Subject	Blind Therapist	Blind Assessor	Adequate Follow up	Intention to treat	Between group comparison	Point Estimates and Variability	Total
Pluchino et al., 2012 *	Y	Y	Y	Y	N	N	N	N	N	Y	Y	5
Ray et al., 2012 *	Y	Y	N	N	N	N	N	N	N	Y	Y	3
Toulotte et al., 2012 *	Y	Y	Y	Y	N	N	N	Y	Y	N	Y	6
Merriman et al., 2015 *	Y	N	N	Y	N	N	N	N	N	Y	Y	3
Sato et al., 2015 *	Y	Y	Y	Y	N	N	N	Y	N	N	Y	5
Whyatt et al., 2015 *	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5
Lai et al., 2013 *	Y	Y	N	Y	N	N	Y	Y	Y	Y	Y	7
Singh et al., 2013 *	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	7
Chow and Mann., 2015 *	N	Y	N	Y	N	N	N	Y	Y	Y	Y	6
Nicholson et al., 2015 *	N	N	N	Y	N	N	N	Y	Y	Y	Y	5
Park et al., 2015 *	Y	N	N	Y	N	N	N	N	Y	Y	Y	4

Tange et al., 2012	Y	N	N	N	N	N	N	Y	N	Y	Y	3
Total	10	8	4	10	0	0	2	8	5	10	12	

RCT = Randomised Control Trial; Non-RCT = Non-Randomised Control Trial; Y = Yes; N = No; * = Included in Meta-Analysis.

Table 2.7a – Outcomes from custom designed quality assessment tool

Author and Date	Research objectives clearly stated	Study Design Clearly Stated	Participant Characteristics Detailed	Inclusion/ Exclusion Criteria Stated	Outcome measures Described	Sample size justified
	1= yes, 0.5= yes lacking detail, 0=no	1= yes, 0.5= yes lacking detail, 0=no	Number, Age, Sex	1= yes, 0.5= yes lacking detail, 0=no	1= yes 0 =no	1= yes 0 =no
Pluchino et al. 2012	1	1	1,1,1	1	1	1
Ray et al. 2012	1	0.5	1,1,1	0.5	0.5	0

Toulotte et al. 2012	1	0.5	1,1,1	1	1	0
Merriman et al. 2015	1	1	1,1,1	0.5	1	0
Sato et al. 2015	0.5	0.5	1,1,0.5	0.5	1	1
Whyatt et al. 2015	1	0.5	1,1,1	0.5	1	0
Lai et al. 2013	0.5	1	1,1,1	0.5	1	0
Singh et al. 2013	1	0	1,1,1	0.5	1	0
Chow and Mann. 2015	0.5	0	1,1,1	0	1	Convenience sample
Nicholson et al. 2015	1	1	1,1,1	0.5	1	Convenience sample
Park et al. 2015	1	0	1,1,1	0.5	1	0
Tange et al. 2012	0.5	1	1,1,0	0.5	1	0

Table 2.7b – Outcomes from custom designed quality assessment tool continued…

Author and Date	Baseline and Post test data presented	Randomization of groups explained	location/settings described	Exergames instrumentation explained (console used, games used	Is duration and intensity of intervention explained?	Are the exergaming and if used, other exercise stated in detail?	Was post intervention follow up used?
	1= yes, 0.5= yes lacking detail, 0=no	1= yes, 0.5= yes lacking detail, 0=no	1= yes 0 =no	1= yes, 0.5= yes lacking detail, 0=no	1= yes, 0.5= yes lacking detail, 0=no	1= yes, 0.5= yes lacking detail, 0=no	1= yes 0 =no
Pluchino et al. 2012	1	1	1	1	1	1	0
Ray et al. 2012	0.5	0	1	0.5	1	0.5	0
Toulotte et al. 2012	0.5	0.5	1	1	1	1	0

Merriman et al. 2015	1	0.5	1	1	1	1	0
Sato et al. 2015	1	1	0	1	1	1	0
Whyatt et al. 2015	1	0	0	1	1	1	0
Lai et al. 2013	1	0.5	0	0.5	1	0.5	0
Singh et al. 2013	1	0	1	0.5	1	1	0
Chow and Mann. 2015	0	0	0	0.5	1	1	0
Nicholson et al. 2015	1	0	1	1	1	0.5	0
Park et al. 2015	1	0	0	1	1	0.5	0
Tange et al. 2012	0.5	0	0	0.5	1	0	0

For quality assessment at the outcome level, the GRADE system considers RCTs to be of high quality and non-RCTs to be of low quality prior to assessment. Outcomes were downgraded from 'high quality' by one level for serious (or by two for very serious) study limitations (risk of bias), indirectness of evidence, serious inconsistency, imprecision of effect estimates or potential publication bias. Studies were then upgraded based on there being a large magnitude of effect, a dose response gradient or plausible confounding factors working against the direction of the effect. Of the 9 outcomes from the SFPC, 7 were reviewed for quality. Cognitive influences and Verticality were excluded as they were not assessed in any of the studies. Outcomes that included data from RCTs only were static stability, reactive postural control and sensory integration. Remaining outcomes also included two non-RCTs (Nicholson et al., 2015, Park et al., 2015). Table 2.8 outlines the 9 outcomes of the SFPC with the number of studies included in the meta-analysis that measured each outcome. Static stability, underlying motor systems, anticipatory postural control and dynamic stability were the most frequently measured outcomes followed by functional stability and sensory integration. Reactive postural control was the least measured outcome and cognitive influences and verticality were not measured using any outcome measure for any of the 11 trials included in the meta-analyses.

Table 2.8 – Frequency of the SFPC outcomes assessed in exergaming interventions

Outcome of SFPC	Studies measured the outcome
Static Stability	11/11
Underlying Motor Systems	11/11
Functional Stability	8/11
Anticipatory PC	11/11
Reactive PC	2/11
Dynamic Stability	11/11
Sensory Integration	8/11
Verticality	0/11
Cognitive Influences	0/11

SFPC = Systems Framework for Postural Control; PC = Postural Control

2.2.3.3 Data extraction

Intervention characteristics are available in Table 2.9. Of the 12 studies included in the review, the overall number of participants taking part in either an exergaming intervention, traditional balance training intervention or no exercise control group was 554. After excluding 1 study from the meta-analysis, the number reduced to 515 participants. Six studies in this review compared an exergaming intervention to a traditional balance training intervention (Pluchino et al., 2012, Ray et al., 2012, Toulotte et al., 2012, Tange et al., 2012, Singh et al., 2013, Park et al., 2015). The other six studies compared an exergaming intervention to a diary of activity or usual activities (Lai et al., 2013, Merriman et al., 2015, Sato et al., 2015, Whyatt et al., 2015, Chow and Mann, 2015, Nicholson et al., 2015). Intervention duration ranged from 5 to 20 weeks, individual sessions ranged from 30 to 60 minutes and session frequency ranged from 1 to 3 times per week. The mean (SD) number of training hours across the 12 studies was 13.5 (8.7). The majority of interventions were conducted in a research facility or a dedicated testing room in a community centre. None of the interventions took place in the home environment and two trials performed exergaming unsupervised (Pluchino et al., 2012, Nicholson et al., 2015). Trials were conducted in the USA (Pluchino et al., 2012, Nicholson et al., 2015, Ray et al., 2012), the UK (Merriman et al., 2015, Whyatt et al., 2015), The Netherlands (Tange et al., 2012), France (Toulotte et al., 2012), Malaysia (Singh et al., 2013), Hong Kong (Chow and Mann, 2015), Japan (Sato et al., 2015), Taiwan (Lai et al., 2013) and South Korea (Park et al., 2015).

Table 2.9 – Overview of the study design, sample characteristics, groups, intervention type and location for included studies

Author and Date	Study Design	Sample: Population; Sample Size (n); age, years (mean ± SD), M/F	Groups	Intervention & Follow up (Y/N)	Location/ Settings
Pluchino et al., 2012	RCPS 3 arms	Community-dwelling older adults, n=40; 72.5 ± 8.4 years, 15/25	Standard Balance Exercise Group (n=14), Tai Chi Group (n=14), Wii Fit Group (n=12)	60 minutes, 2 x per week, 8 weeks. (N)	Research laboratory/training facility, Wii group unsupervised.
Ray et al., 2012	RCT 3 arms	Community-dwelling older adults, n=87, 75 years (no SD given), 29/58	Group Fitness (n=40), Wii Fitness + weighted vest(n=29), Control Group (n=18)	GF & WF: 3 x week 45 mins duration, 15 weeks. (N)	Laboratory

Toulotte et al., 2012	RCT 4 arms	Community-dwelling older adults., n=36, 14/22. See adjacent column for mean age (SD) per group	G1: Adapted Physical Activities, (n=9, 84.2 ± 8.1 years, 3/6). G2: Wii Fit, (n=9, 72.2 ± 8.6 years 4/5). G3: APA + WF, (n=9, 76.4 ± 4.7 years, 3/6). G4: CG (n=9, 71.8 ± 8.0, 4/5).	60 minutes per week x 20 weeks. (N)	Gymnasium at retirement centre
Merriman et al., 2015	RCT 2 arms	Community-dwelling n=59 & Retired Persons n=17, subgroups: healthy n=42, fall prone n=34, 16/60. See adjacent column for mean age (SD) per group	(IG) Balance Training (n=38, 17 his of falls, 74.06 (6.66) years, 21 healthy, 74.90 (8.97) years, 1/37). (CG) Control Group (n=38, 17 his of falls 73.41 (7.00) years, 21 healthy 74.33 (11.09) years, 15/23)	IG:5 weeks, 2 x 30 min BT/week CG: diary of light, med, heavy Physical Activity. (N)	Dedicated Testing rooms at Sheltered accommodation or community centre, Alt in a testing laboratory
Sato et al., 2015	RCT 2 arms	Community-dwelling older adults, n=54, 69.25 ± 5.4 years, 11/43	Intervention Group (n=29) Control Group (n=28)	65.34 (9.63) days, 40 mins – 1	N/A

				hour per session, 2-3 times per week, total 24 times. (N)	
Whyatt et al., 2015	RCT 2 arms	Sheltered accommodation and local activity groups, n=84, 25/57. See adjacent column for mean age (SD) per group	(IG) Balance Game Training, n=40, 77.18– 6.59 years, 5/35. (CG)Control Group n=42, 76.62– 7.28 years 20/22. Subgroups. High Risk Falls: IG (n=15, 77.73 – 8.01 years, 2/13). CG (n=12, 79.00 – 7.03 years, 6/6). Low Risk Falls: IG (n=25, 76.83– 5.64 years 3/22). CG; (n=30, 75.67 – 7.28 years, 14/16).	(IG) 30 minutes per session, 10 x sessions; over 5 weeks. (CG) 5 weeks of recording levels of	N/A

				physical activity. (N)	
Lai et al., 2013	RCT 2 arms	Community-living persons n=30, 72.1 [4.8] years, 13/17	Group A: (n=15, 70.6 (3.5) years 7/8). Group B: (n=15, 74.8 (4.7) years, 6/9). Both Groups performed an intervention phase and a control phase.	12 weeks trial. (IG) 30 mins, 3 times/ week x 6 weeks then 6 weeks no exercise. (CG) no exercise x 6 weeks then IVGB 6weeks. (N)	N/A

Singh et al., 2013	RCT 2 arms	Community-dwelling older women, n=38, 36 completed intervention.	(IG): balance-focused virtual-reality games 61.12 (3.72) years, (CG): therapeutic balance exercises: 64.00 (5.88) years,	30 minutes, 2 x / week for 6 weeks. (N)	N/A
Chow and Mann, 2015	RCPS 2 arms	Community-dwelling, n=20, 69 (range 65 – 78), 7/13	(IG): Daily Cyber Golfing n=10, 70.4 (5.4) years, 3/7 CG: regular table games n=10, 68.0 (3.0) years, 4/6.	Daily, 30-45 minutes for 2 weeks. (N)	N/A
Nicholson et al., 2015	Two-group repeated measures study	Local retirement villages and educational settings, n=41, 74.5 (5.4) years, 14/27	(IG)Wii group (n = 19, 75.11 (5.85) years, 7/12, 2 fallers). (CG) comparison group (n = 22, 73.91 (5.12 years, 7/15, 3 fallers)	(IG): 3 × 30 min Wii Fit sessions per week for six weeks. (CG): usual everyday activities	Unsupervised, in pairs in community hall of a retirement village

				and exercise routines. (N)	
Park et al., 2015	Two-group repeated measures study	Community Dwelling Individuals, n=30	virtual reality game group (n=15, 66.5±8.1 years, 9/3) and a ball exercise group (n=15, 65.2±7.9 years, 10/2)	30 min 3 times a week for 8 weeks. (N)	N/A
Tange et al., 2012	Two-group repeated measu	Elderly individuals, n=39,	Wii Sports Group n=20 77 (68-82) years, Wii Fit Group: n=19, 84 (80-89) years	2 x / week during 6 weeks in one-hour sessions. (N)	N/A

res

study

RCT= Randomised Controlled Trial; RCPS = Randomised Controlled Pilot Study; SD = Standard Deviation; M/F = Male/Female; Y/N = Yes/No; GF = Group Fitness; WF = Wii Fitness; G1,2,3 and 4 = Group 1, 2,3 and 4; APA = Adapted Physical Activities; CG = Control Group; IG = Intervention Group; his = history; mins = minutes.

2.2.3.4 Intervention effect

The outcomes from the SFPC that had sufficient data and a sufficient number of studies to be included in the meta-analysis were static stability, underlying motor systems, functional stability limits, anticipatory postural control, dynamic stability and sensory integration. Reactive postural control had insufficient data to collate into a meta-analysis and cognitive influences and verticality was not measured in any of the studies.

2.2.3.4.1 Effects of exergaming for outcomes of the SFPC

Static stability

Overall, improvements in static stability did not favour either an exergaming intervention or controls (SMD: 0.06, 95% CI = −0.29 to 0.41; I^2 = 72%) based on data from 515 participants in 11 studies. Results were analysed using a random-effects model because there were some very serious concerns for risk of bias and inconsistency. There were also serious concerns for indirectness and imprecision and a substantial level of statistical heterogeneity (Chi^2 and I^2). Sub-group analysis separated comparison group type (exergaming versus traditional intervention and no intervention). Interestingly, after accounting for control group type, the sub-group effect estimate made a small shift toward of exergaming when compared to traditional balance intervention, although no real differences could be observed which suggests that an exergaming intervention is as beneficial as a traditional balance intervention for improving static stability for older adults (SMD: -0.01, 95% CI = -0.69 to 0.68; I^2 = 72%). When assessing exergaming versus no intervention, the effect estimate made a shift in favour of no intervention (SMD: 0.11, 95% CI = -0.31 to 0.53; I^2 = 71%). The observable effects must be taken with caution as the quality of evidence for this outcome was downgraded by 2 levels from high to low quality as the RCTs had some serious study limitations (no reporting of sequence generation, lack of allocation concealment, lack of blinding or participants and assessors, lack of intention to treat analysis and selective outcome reporting) and the evidence from non-RCTs was not sufficient to be upgraded (Figure 2.1).

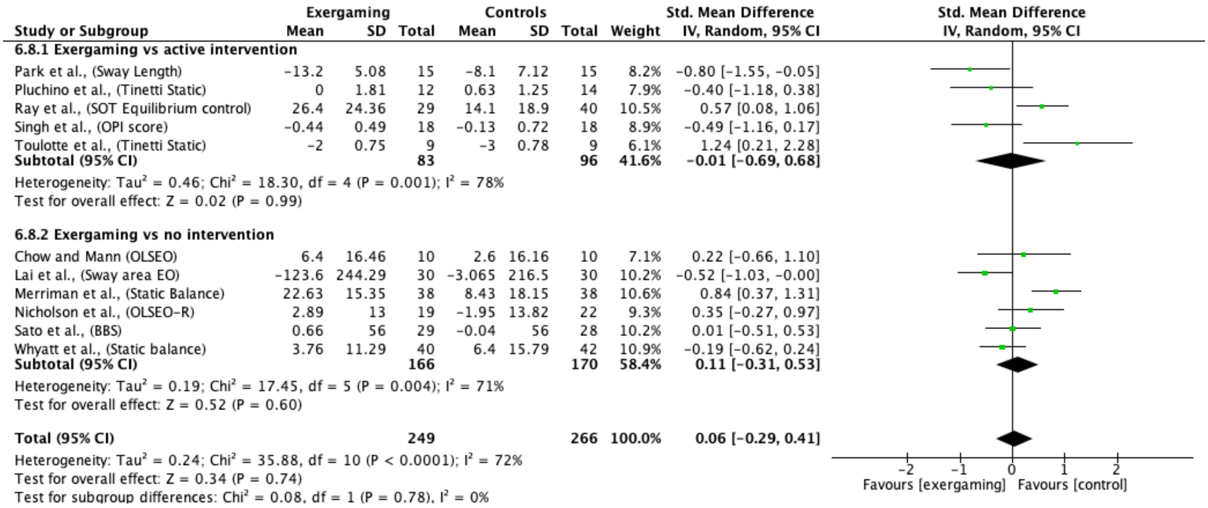

Figure 2.1 – The effects of an exergaming intervention versus an active balance intervention or no intervention on static stability of community-dwelling older adults

Underlying motor systems

Improvement in underlying motor systems did not favour an exergaming intervention or controls (SMD: 0.01, 95% CI = −0.32 to 0.35; I^2 = 70%) based on data from 515 participants in 11 studies. Results were analysed using a random-effects model because there were some very serious concerns for risk of bias and inconsistency. There were also some serious concerns for indirectness and imprecision and a substantial level of statistical heterogeneity (Chi^2 and I^2). Sub-group analysis revealed that there was an overall small effect in favour of an active intervention for training the underlying motor systems involved in maintaining postural control such as strength and coordination (SMD: 0.37, 95% CI = -0.27 to 1.01, I^2 = 75%). Exergaming versus no intervention (recording physical activity in a diary or attending to usual physical activity) showed a small effect in favour of exergaming (SMD: -0.20, 95% CI = -0.58 to 0.17, I^2 = 64%) (Figure 2.2).

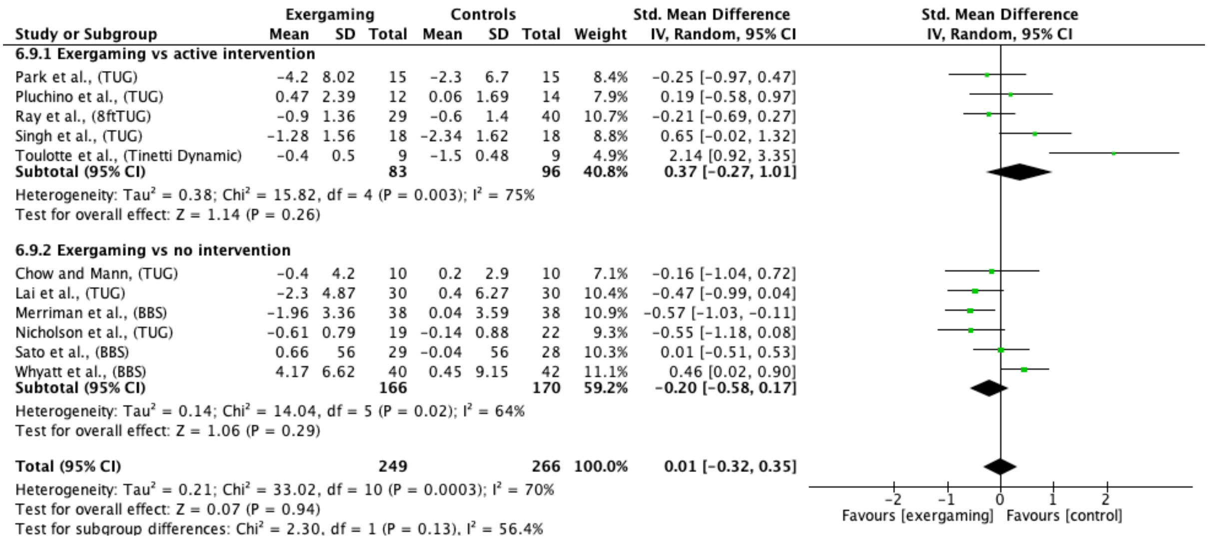

Figure 2.2 - The effects of an exergaming intervention versus an active balance intervention or no intervention on the underlying motor systems of community-dwelling older adults

Functional stability limits

Results for assessment of functional stability limits showed a small effect in favour controls based on data from 380 participants in 8 studies (SMD: 0.39, 95% CI = −0.02 to 0.80; I^2 = 72%). Sub-group analysis showed a large effect in favour of an active intervention (SMD: 0.67, 95% CI = −0.33 to 1.67; I^2 = 59%) and a small effect in favour of no intervention (SMD: 0.33, 95% CI = −0.15 to 0.80; I^2 = 78%) compared to exergaming. Results were analysed using a random-effects model because there were some serious concerns for risk of bias, inconsistency, indirectness and imprecision and a substantial level of statistical heterogeneity (Chi^2 and I^2) (Figure 2.3).

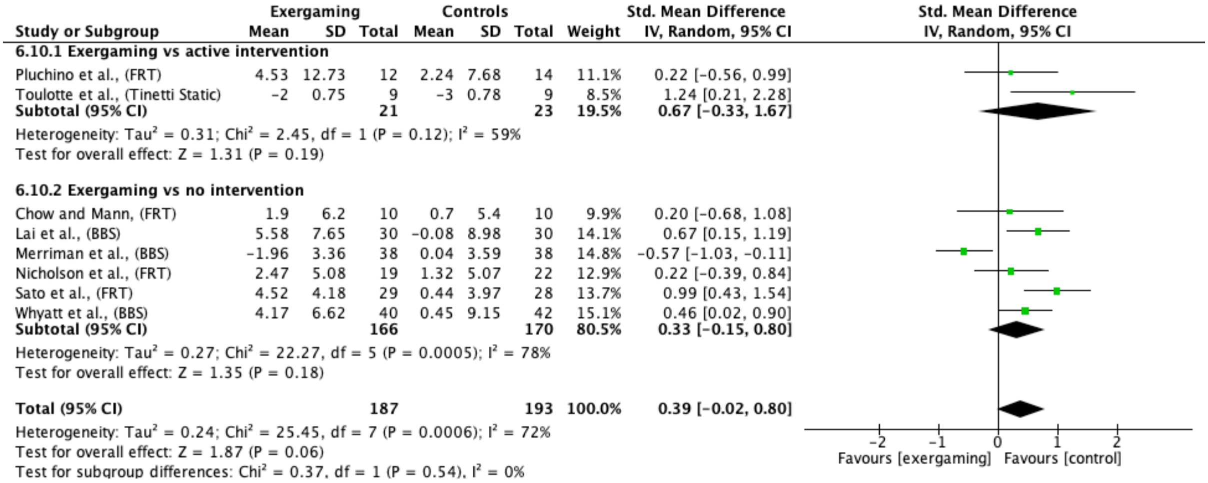

Figure 2.3 - The effects of an exergaming intervention versus an active balance intervention or no intervention on the functional stability limits of community-dwelling older adults

Dynamic stability

Exergaming appears to be equally as beneficial as a combination of active and inactive controls at improving dynamic stability (SMD: 0.01, 95% CI = -0.32, 0.35; I^2 = 70%) based on data from 515 participants across 11 studies. Sub-group analysis saw a small shift in the effect estimate in favour of exergames when compared to a group receiving no intervention (SMD: -0.20, 95% CI = -0.58, 0.17; I^2 = 64%). When comparing exergaming to alternative balance interventions, the effect estimate shifted in favour of the groups receiving alternative balance training (SMD: 0.37, 95% CI = -0.27, 1.01; I^2 = 75%). Results were analysed using a random-effects model because there were some serious concerns for risk of bias, inconsistency, indirectness and imprecision and a substantial level of statistical heterogeneity (Chi^2 and I^2) (Figure 2.4).

	Exergaming			Controls				Std. Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
6.13.1 Exergaming vs active intervention								
Park et al., (TUG)	−4.2	8.02	15	−2.3	6.7	15	8.4%	−0.25 [−0.97, 0.47]
Pluchino et al., (TUG)	0.47	2.39	12	0.06	1.69	14	7.9%	0.19 [−0.58, 0.97]
Ray et al., (8ftTUG)	−0.9	1.36	29	−0.6	1.4	40	10.7%	−0.21 [−0.69, 0.27]
Singh et al., (TUG)	−1.28	1.56	18	−2.34	1.62	18	8.8%	0.65 [−0.02, 1.32]
Toulotte et al., (Tinetti Dynamic)	−0.4	0.5	9	−1.5	0.48	9	4.9%	2.14 [0.92, 3.35]
Subtotal (95% CI)			**83**			**96**	**40.8%**	**0.37 [−0.27, 1.01]**
Heterogeneity: Tau² = 0.38; Chi² = 15.82, df = 4 (P = 0.003); I² = 75%								
Test for overall effect: Z = 1.14 (P = 0.26)								
6.13.2 Exergaming vs no intervention								
Chow and Mann, (TUG)	−0.4	4.2	10	0.2	2.9	10	7.1%	−0.16 [−1.04, 0.72]
Lai et al., (TUG)	−2.3	4.87	30	0.4	6.27	30	10.4%	−0.47 [−0.99, 0.04]
Merriman et al., (BBS)	−1.96	3.36	38	0.04	3.59	38	10.9%	−0.57 [−1.03, −0.11]
Nicholson et al., (TUG)	−0.61	0.79	19	−0.14	0.88	22	9.3%	−0.55 [−1.18, 0.08]
Sato et al., (BBS)	0.66	56	29	−0.04	56	28	10.3%	0.01 [−0.51, 0.53]
Whyatt et al., (BBS)	4.17	6.62	40	0.45	9.15	42	11.1%	0.46 [0.02, 0.90]
Subtotal (95% CI)			**166**			**170**	**59.2%**	**−0.20 [−0.58, 0.17]**
Heterogeneity: Tau² = 0.14; Chi² = 14.04, df = 5 (P = 0.02); I² = 64%								
Test for overall effect: Z = 1.06 (P = 0.29)								
Total (95% CI)			**249**			**266**	**100.0%**	**0.01 [−0.32, 0.35]**
Heterogeneity: Tau² = 0.21; Chi² = 33.02, df = 10 (P = 0.0003); I² = 70%								
Test for overall effect: Z = 0.07 (P = 0.94)								
Test for subgroup differences: Chi² = 2.30, df = 1 (P = 0.13), I² = 56.4%								

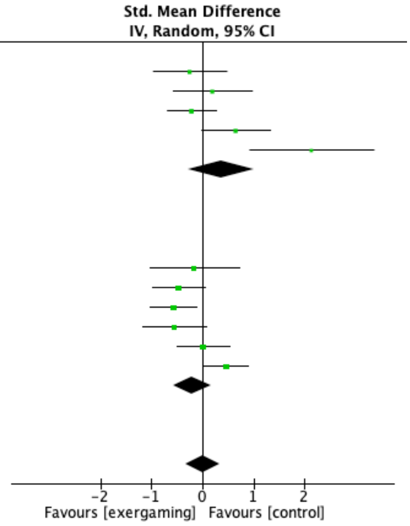

Figure 2.4 - The effects of an exergaming intervention versus an active balance intervention or no intervention on dynamic stability of community-dwelling older adults

Sensory integration

Exergaming appears to be less beneficial at improving sensory integration outcomes when compared to a combination of active and inactive controls (SMD: 0.17, 95% CI = -0.26, 0.60; I^2 = 78%) based on data from 424 participants across 8 studies that measured the outcome. Sub-group analysis revealed a very small shift of the effect estimate in the direction of exergames when compared to a group receiving no intervention but will no real impact (SMD: 0.14, 95% CI = -0.41, 0.69; I^2 = 81%). When comparing exergaming to alternative balance interventions, the effect estimate shifted further in favour of the groups receiving alternative balance training (SMD: 0.22, 95% CI = -0.60, 1.05; I^2 = 81%). Results were analysed using a random-effects model because there were some serious concerns for risk of bias, inconsistency, indirectness and imprecision and a substantial level of statistical heterogeneity (Chi^2 and I^2) (Figure 2.5).

Study or Subgroup	Exergaming Mean	Exergaming SD	Exergaming Total	Controls Mean	Controls SD	Controls Total	Weight	Std. Mean Difference IV, Random, 95% CI
6.14.1 Exergaming vs active intervention								
Pluchino et al., (Tinetti Dynamic)	0.2	0.86	12	0.62	0.65	14	10.7%	−0.54 [−1.33, 0.25]
Ray et al., (SOT Equilibrium control)	26.4	24.36	29	14.1	18.9	40	13.8%	0.57 [0.08, 1.06]
Singh et al., (OPI score)	−0.44	0.49	18	−0.13	0.72	18	12.0%	−0.49 [−1.16, 0.17]
Toulotte et al., (OLSEC)	−4.8	5.05	9	−11.7	2.95	9	8.0%	1.59 [0.49, 2.68]
Subtotal (95% CI)			**68**			**81**	**44.6%**	**0.22 [−0.60, 1.05]**
Heterogeneity: Tau² = 0.56; Chi² = 15.95, df = 3 (P = 0.001); I² = 81%								
Test for overall effect: Z = 0.53 (P = 0.60)								
6.14.2 Exergaming vs no intervention								
Lai et al., (BBS)	5.58	7.65	30	−0.08	8.98	30	13.5%	0.67 [0.15, 1.19]
Merriman et al., (BBS)	−1.96	3.36	38	0.04	3.59	38	14.1%	−0.57 [−1.03, −0.11]
Sato et al., (BBS)	0.66	56	29	−0.04	56	28	13.5%	0.01 [−0.51, 0.53]
Whyatt et al., (BBS)	4.17	6.62	40	0.45	9.15	42	14.3%	0.46 [0.02, 0.90]
Subtotal (95% CI)			**137**			**138**	**55.4%**	**0.14 [−0.41, 0.69]**
Heterogeneity: Tau² = 0.25; Chi² = 15.40, df = 3 (P = 0.002); I² = 81%								
Test for overall effect: Z = 0.50 (P = 0.62)								
Total (95% CI)			**205**			**219**	**100.0%**	**0.17 [−0.26, 0.60]**
Heterogeneity: Tau² = 0.29; Chi² = 31.45, df = 7 (P < 0.0001); I² = 78%								
Test for overall effect: Z = 0.76 (P = 0.45)								
Test for subgroup differences: Chi² = 0.03, df = 1 (P = 0.87), I² = 0%								

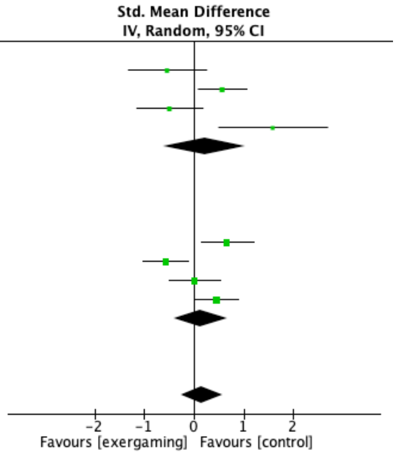

Figure 2.5 - the effects of an exergaming intervention versus an active balance intervention or no intervention on sensory integration of community-dwelling older adults

Anticipatory postural control

Exergaming appears to be equally as beneficial as a combination of active and inactive controls at improving anticipatory postural control mechanisms (SMD: 0.01, 95% CI = -0.32, 0.35; I^2 = 70%) based on data from 515 participants across 11 studies. Sub-group analysis saw a small shift in the effect estimate in favour of exergames when compared to a group receiving no intervention (SMD: -0.20, 95% CI = -0.58, 0.17; I^2 = 64%). When comparing exergaming to alternative balance interventions, the effect estimate shifted in favour of the groups receiving alternative balance training (SMD: 0.37, 95% CI = -0.27, 1.01; I^2 = 75%). Results were analysed using a random-effects model because there were some serious concerns for risk of bias, inconsistency, indirectness and imprecision and a substantial level of statistical heterogeneity (Chi^2 and I^2) (Figure 2.6).

Study or Subgroup	Exergaming Mean	Exergaming SD	Exergaming Total	Controls Mean	Controls SD	Controls Total	Weight	Std. Mean Difference IV, Random, 95% CI
6.11.1 Exergaming vs active intervention								
Park et al., (TUG)	−4.2	8.02	15	−2.3	6.7	15	8.4%	−0.25 [−0.97, 0.47]
Pluchino et al., (TUG)	0.47	2.39	12	0.06	1.69	14	7.9%	0.19 [−0.58, 0.97]
Ray et al., (8ftTUG)	−0.9	1.36	29	−0.6	1.4	40	10.7%	−0.21 [−0.69, 0.27]
Singh et al., (TUG)	−1.28	1.56	18	−2.34	1.62	18	8.8%	0.65 [−0.02, 1.32]
Toulotte et al., (Tinetti Dynamic)	−0.4	0.5	9	−1.5	0.48	9	4.9%	2.14 [0.92, 3.35]
Subtotal (95% CI)			**83**			**96**	**40.8%**	**0.37 [−0.27, 1.01]**
Heterogeneity: Tau² = 0.38; Chi² = 15.82, df = 4 (P = 0.003); I² = 75%								
Test for overall effect: Z = 1.14 (P = 0.26)								
6.11.2 Exergaming vs no intervention								
Chow and Mann, (TUG)	−0.4	4.2	10	0.2	2.9	10	7.1%	−0.16 [−1.04, 0.72]
Lai et al., (TUG)	−2.3	4.87	30	0.4	6.27	30	10.4%	−0.47 [−0.99, 0.04]
Merriman et al., (BBS)	−1.96	3.36	38	0.04	3.59	38	10.9%	−0.57 [−1.03, −0.11]
Nicholson et al., (TUG)	−0.61	0.79	19	−0.14	0.88	22	9.3%	−0.55 [−1.18, 0.08]
Sato et al., (BBS)	0.66	56	29	−0.04	56	28	10.3%	0.01 [−0.51, 0.53]
Whyatt et al., (BBS)	4.17	6.62	40	0.45	9.15	42	11.1%	0.46 [0.02, 0.90]
Subtotal (95% CI)			**166**			**170**	**59.2%**	**−0.20 [−0.58, 0.17]**
Heterogeneity: Tau² = 0.14; Chi² = 14.04, df = 5 (P = 0.02); I² = 64%								
Test for overall effect: Z = 1.06 (P = 0.29)								
Total (95% CI)			**249**			**266**	**100.0%**	**0.01 [−0.32, 0.35]**
Heterogeneity: Tau² = 0.21; Chi² = 33.02, df = 10 (P = 0.0003); I² = 70%								
Test for overall effect: Z = 0.07 (P = 0.94)								
Test for subgroup differences: Chi² = 2.30, df = 1 (P = 0.13), I² = 56.4%								

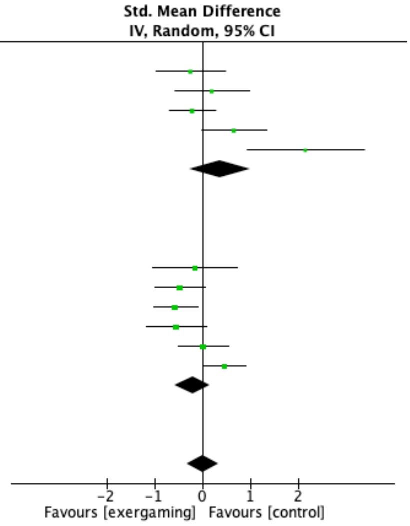

Figure 2.6 - the effects of an exergaming intervention versus an active balance intervention or no intervention for anticipatory postural control of community-dwelling older adults

Overall, at the outcome level, the effects of exergames compared to traditional balance training interventions show that exergaming is as beneficial at improving outcomes of postural control, but the results must be taken with caution. The sub-group analysis at the outcome level showed that in some cases, not receiving an intervention and going about usual activities or keeping a diary of physical activity was as beneficial as being involved in an exergaming intervention. The quality of evidence for each outcome in this meta-analysis was low and shows there is room for more high quality and robust RCTs to contribute evidence on the effects of exergames at improving postural control. These include adequate sequence generation, improved blinding procedures for participants, providers and outcome assessors, greater use of intention to treat analysis, sufficient reporting of outcomes which cover the all areas of postural control as well as other biases. The inconsistency observed in all outcomes can be attributed to variation in comparison groups, length of the intervention period and the studies including populations with and without fall status may contribute to the indirectness of the effect estimate. The imprecision observed within each of the outcomes is not due to the number of participants included in each meta-analysis. Although, for functional stability limits, there were 380 participants when going by the rule of thumb of 400 minimum is recommended by GRADE for a more precise effect estimate. This may account for the larger effect estimate for all sub-group meta-analyses. In many cases throughout these meta-analyses, the confidence interval (either upper or lower) is greater than 0.5 which supports the statement of the imprecision observed in the effect size. Imprecision of the effect estimate increased when sub-groups were introduced into the analysis, which could be attributed to the reduced number of participants contributing to each sub-group effect estimate. Due to not including grey literature in the search of this review and the moderate number of studies included in each outcome, the power of the publication bias tests was too low to distinguish chance from real asymmetry. In the case for the outcomes included in this review, the reasons for downgrading are the same for all of the outcomes and the GRADE assessment table representing all outcomes is presented below in Table 2.10.

Table 2.10 – GRADE assessment for outcomes of the SFPC for community-dwelling older adults

GRADE Criteria	Rating	Reasons	Quality of the evidence
Baseline GRADE level	High		
Risk of Bias	Very serious (-2)	Crucial risk of bias for one criterion, or multiple criteria, and likely to seriously alter the results.	2/4 (Low)
Inconsistency	Serious (-1)	The effect estimate varies in direction but not really in size and the CI overlap in most studies. There is serious concern in inconsistency.	
Indirectness	Serious (-1)	Differences in the population, intervention characteristics, comparison, group type and no long-term effects of outcomes assessed.	

Imprecision	Serious (-1)	Downgrade as the upper confidence limit crosses effect size (above 0.5, recommended to downgrade)
Publication bias	Serious (-1)	Grey literature not searched. Small study size for all studies (max No. of participants in a study = 82). Due to small number of studies included in this outcome, the power of the tests is too low to distinguish chance from real asymmetry.
Other bias	No evidence to upgrade	

GRADE = Grading of Recommendations, Assessment, Development and Evaluations; CI = Confidence interval.

Reactive postural control

Reactive postural control could not be included in the meta-analysis as too few studies included the outcome and there was insufficient data available. Briefly, only two studies assessed reactive postural control, both within the dynamic balance section of the Tinetti POMA (Pluchino et al., 2012, Toulotte et al., 2012). The quality of the included studies for this outcome was equal to that of the other 10 studies reviewed for each outcome, which was of low quality. Both studies compared exergaming to a traditional balance-based intervention and interestingly, one study found exergaming to be more beneficial at improving reactive postural control (Pluchino et al., 2012), whereas the other study found adapted physical exercise intervention more beneficial at improving reactive postural control (Toulotte et al., 2012). Both studies had a low number of participants and there was a significant level of variation between the two studies, such as frequency of sessions per week overall number of weeks of the intervention and one study exergaming group was unsupervised. Further investigation is warranted into the effects of exergames on reactive postural control through more robust RCTs in greater numbers.

2.2.3.4.2 Effects by type of measure (Primary and Secondary)

An overview of primary, secondary and tertiary outcome measures used to assess balance can be found in Table 2.11. Of the 11 trials included in the meta-analysis, six reported postural control outcomes from rating scales (Pluchino et al., 2012, Toulotte et al., 2012, Lai et al., 2013, Merriman et al., 2015, Whyatt et al., 2015, Sato et al., 2015), four reported stand and reach tasks, one reported a sit and reach task (Pluchino et al., 2012, Ray et al., 2012, Chow and Mann, 2015, Nicholson et al., 2015, Sato et al., 2015) and seven trials included timed tasks consisting of standing balance and mobility assessment (Chow and Mann, 2015, Pluchino et al., 2012, Nicholson et al., 2015, Ray et al., 2012, Singh et al., 2013, Lai et al., 2013, Park et al., 2015). Data for included studies can be viewed in each figure. Five trials used self-report methods to quantify balance confidence and fear of falling (Pluchino et al., 2012, Nicholson et al., 2015, Merriman et al., 2015, Whyatt et al., 2015, Lai et al., 2013). Four trials used various versions of the falls efficacy scale (Pluchino et al., 2012, Nicholson et al., 2015, Merriman et al., 2015, Lai et al., 2013). Two trials administered the ABC scale (Merriman et al., 2015, Whyatt et al., 2015), one trial administered fall risk for older individuals living in the community (Pluchino et al., 2012) and one trial administered a questionnaire to measure fear of falling (Merriman et al., 2015).

Table 2.11 - Overview of primary, secondary and tertiary outcome measures used to assess balance

Author and Date	Systems and apparatus	Primary OMs	Secondary OMs	Tertiary OMs	Details
Pluchino et al., 2012	AccuSway Force Platform, Proprio 5000 Dynamic Posturography platform	One-Leg Stance (s), Functional Reach Test (cm), Timed Up & Go Test (s), Tinetti Performance Oriented Mobility Assessment	Falls Efficacy Scale (FES), Falls Risk for Older People–Community Setting (FROP-COM).	The Postural Sway Test (COP + Time to boundary), Dynamic Posturography Test (perturbation platform)	Postural Sway Test Parameters: COP characteristics in AP and ML direction
Ray et al., 2012	NeuroCom SOT	8ft Timed Up and Go Test (s), Chair stand x 15-25 reps weighted, 6-minute walk test, Sit and Reach Test.	N/A	Sensory Organisation Test: 6 conditions, 3 trials/ condition. 18 trials total. 20 s/ trial.	Composite Equilibrium Score of weighted value of 6 conditions: Strategy Analysis score: Scores between 0 and 100 represent a combination of the two strategies; ankle and hip.
Toulotte et al., 2012	Nintendo Wii Fit + WBB	Unipedal Test Eyes Open, Eyes Closed, Tinetti Balance Assessment tool.	N/A	Wii Fit Test - Position of Centre Of Gravity (COG)	The videogame console gives two percentages (right and left) for the position of the centre of gravity. We calculated the percentage difference between right and left and concluded as to the overall position of the centre of gravity.
Merriman et al., 2015	Wii Balance Board (embedded with safety frame surrounding)+	Berg Balance Scale	Balance Confidence (ABC) Scale, Fear of Falling (FOF) Falls	Static and Dynamic Balance Test.	Static: No. of secs within target area (max 10) converted to a percentage. 3 trials per target zone and average score across trials was collected.

	Custom Designed Game		Efficacy Scale (FES)		Dynamic: No of time to reach targets at fixed locations in 60s.
Sato et al., 2015	N/A	Berg Balance Scale, Functional Reach Test (cm), Chair Stand-30s	N/A	N/A	N/A
Whyatt et al., 2015	Nintendo Wii Fit, Wii Balance Board, Zimmer frame for safety, The NeuroCom Balance Master	Berg Balance Scale	ABC Scale	Custom made Static Balance Test (COP Displacement), Dynamic Balance Test - Limits of stability (COP)	Static: percentage of time spent in the target area. Dynamic: No. of targets hit COP displacement. Scores represent levels of COP spatial accuracy and data for all balance tests were converted to percentage change between Session 1 and Session 2.
Lai et al., 2013	The Catsys 2000 system measures postural sway, Xavix Measured Step System (XMSS)	Berg Balance Scale, Timed Up and Go Test (s), Unipedal Stance Test, XMSS stepping test	Modified Falls Efficacy Scale (MFES)	Stepping Test, Sway Area (SA), postural sway (Sway Velocity (SV) of COP in bipedal stance with eyes open and closed)	Sway Area (SA) and Sway Velocity (SV) COP in a bipedal stance with eyes open and closed. Postural sway was measured for 75 s (standard test procedure: 10 s start-up period, 60 s recording period, and 5 s run-out period), while standing directly on the platform
Singh et al., 2013	Probalance System	Timed up and Go Test (s), Ten Step Test		Postural Sway	Anterior –posterior and medial – lateral sway scores were converted to an overall performance index (OPI) by the Probalance software program. Lower OPI scores reflect better ability to regulate postural sway.

Chow and Mann, 2015	N/A	Timed up and go test (s), Single leg stance test, Functional Reach test (cm).	N/A	N/A
Nicholson et al., 2015	N/A	Timed Up and Go Test (s) Functional reach (cm) Lateral reach left (cm) Lateral reach right (cm) Single Leg Stance left (s) Single Leg Stance right (s) 30-s chair stand, Gait speed (m/s)	N/A	N/A
Park et al., 2015	BioRescue	Timed Up and Go Test (s)	Static Balance	30 sec sway length (mm) & average sway speed (mm^2) EO (COP) + biofeedback
Tange et al., 2012	N/A	Berg Balance Scale at 0, 3, and 6 weeks	N/A	N/A

OMs = Outcome measures; N/A = Not Applicable; COP = Centre of Pressure; SOT = Sensory Organisation Test; (s) = seconds; (cm) = centimetres; (m/s) = metres per second; mm2 = millimetres squared; EO = Eyes Open

Exergaming had less of an effect on postural control than controls either taking part in a traditional balance training intervention or no intervention when measured using rating scales (SMD: 0.27, 95% CI = −0.23 to 0.78; I^2 = 80%) (Figure 2.7) and distance-based reaching tasks (SMD: 0.22, 95% CI −0.35 to 0.78, I^2 = 75%) (Figure 2.8) but no differences were observed in the effect for timed tasks (SMD: 0.02, 95% CI −0.27 to 0.30; I^2 = 54%) (Figure 2.9). Exergaming had less of an effect on balance confidence and fear of falling than controls when measured using questionnaires (SMD: 0.23, 95% CI = 0.03 to 0.44; I^2 = 0%) and results for the pooled effect estimate were statistically significant (Figure 2.10).

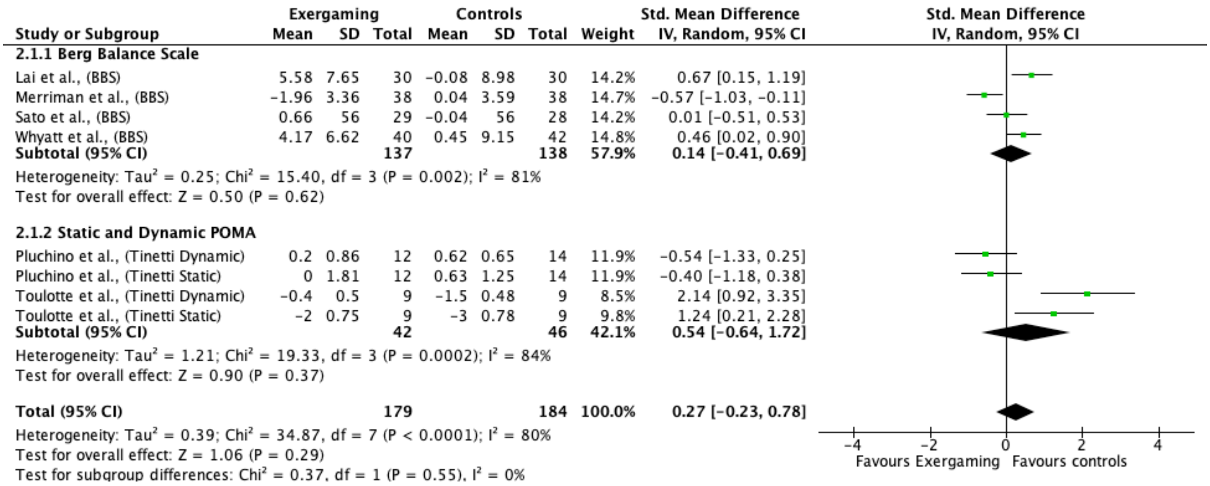

Figure 2.7 - Outcome measures using rating scales for postural control assessment in exergaming vs. controls. BBS = Berg balance scale; POMA = Performance Oriented Mobility Assessment; Std. = standardised; IV = inverse variance; CI = confidence interval.

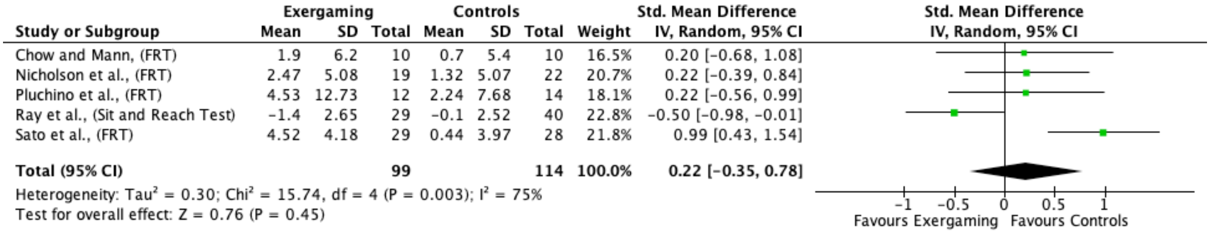

Figure 2.8 - Outcome measures using reaching tasks for exergaming vs. controls. FRT = Functional Reach Test; Std. = standardised; IV = inverse variance; CI = confidence interval.

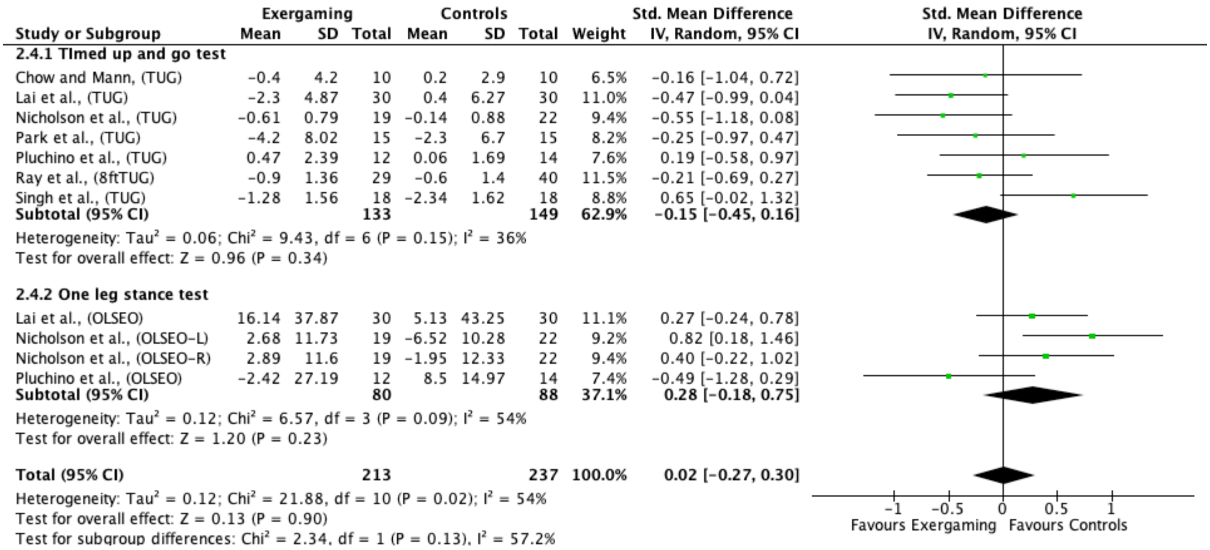

Figure 2.9 - Outcome measures using timed tasks for exergaming vs. controls. TUG = Timed Up and Go; OLSEO = One Leg Stance Eyes Open; Std. = standardised; IV = inverse variance; CI = confidence interval.

Study or Subgroup	Exergaming Mean	Exergaming SD	Exergaming Total	Controls Mean	Controls SD	Controls Total	Weight	Std. Mean Difference IV, Random, 95% CI
2.5.1 Balance confidence								
Merriman et al., (ABC)	11.61	17.43	38	4.92	21.45	38	19.6%	0.34 [−0.11, 0.79]
Whyatt et al., (ABC)	20.4	12.95	40	13.175	21.61	42	21.1%	0.40 [−0.04, 0.84]
Subtotal (95% CI)			**78**			**80**	**40.7%**	**0.37 [0.06, 0.68]**
Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.04$, df = 1 (P = 0.85); $I^2 = 0\%$								
Test for overall effect: Z = 2.31 (P = 0.02)								
2.5.2 Fear of falling								
Lai et al., (MFES)	6.5	18.29	30	−0.44	20.03	30	15.5%	0.36 [−0.15, 0.87]
Merriman et al., (FES)	−3.84	10.13	38	−5.04	21.19	38	19.9%	0.07 [−0.38, 0.52]
Nicholson et al., (I–FES)	0.58	1.55	19	0.58	1.55	22	10.7%	0.00 [−0.61, 0.61]
Pluchino et al., (FES)	−2.8	7.48	12	−1	2.09	14	6.7%	−0.33 [−1.11, 0.45]
Pluchino et al., (FROP–COM)	1.7	3.96	12	−0.2	2.65	14	6.5%	0.56 [−0.23, 1.34]
Subtotal (95% CI)			**111**			**118**	**59.3%**	**0.14 [−0.12, 0.40]**
Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 3.45$, df = 4 (P = 0.49); $I^2 = 0\%$								
Test for overall effect: Z = 1.06 (P = 0.29)								
Total (95% CI)			**189**			**198**	**100.0%**	**0.23 [0.03, 0.44]**
Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 4.69$, df = 6 (P = 0.58); $I^2 = 0\%$								
Test for overall effect: Z = 2.29 (P = 0.02)								
Test for subgroup differences: $Chi^2 = 1.21$, df = 1 (P = 0.27), $I^2 = 17.2\%$								

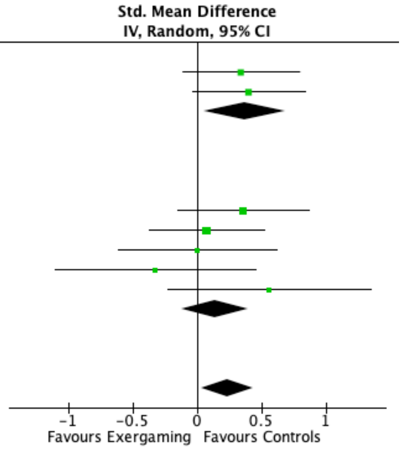

Figure 2.10 - Self-Report Measures of balance confidence and fear of falling for exergaming vs. controls. FES = Falls Efficacy Scale; ABC = Activities-specific Balance Confidence Scale; FROP-COM = Falls Risk for Older People living in the Community; I = Iconographical and M = Modified; Std. = standardised; IV = inverse variance; CI = confidence interval.

After excluding non-RCT's to observe for any differences in the direction of the effect, the exclusion made no change for rating scales as only RCTs were included in the meta-analysis initially. For distance-based reaching tasks there was minimal change to the direction of the effect (SMD: 0.22, 95% CI −0.52 to 0.96, I^2 = 81%) (Figure 2.11) and marginally for timed tasks (SMD: -0.04, 95% CI −0.35 to 0.28, I^2 = 42%) (Figure 2.12), though remained statistically insignificant. Exergaming remained to have less of an effect on balance confidence and fear of falling than controls when measured using questionnaires (SMD: 0.26, 95% CI = 0.05 to 0.47; I^2 = 0%), with results of the pooled effect estimate remaining statistically significant without the inclusion of non-RCTs (Figure 2.13). A noticeable reduction in heterogeneity was observed for timed-tasks whereas there was a noticeable increase for distance based reaching tasks suggesting changes in the percentage of variance without the inclusion of non-RCTs and there was no change in heterogeneity for self-report questionnaires.

There were several findings from primary and secondary outcome measures with insufficient data to pool into meta-analysis. One trial used a version of the single leg stance test and counted the number of times an individual's foot touched the floor for both eyes open and closed conditions (Park et al., 2015), one trial (Toulotte et al., 2012) assessed gait speed and found a significant (P < 0.01) improvement of 0.04 m/s-1 in the exergaming group. Another trial performed a distance-based 6-minute walk test, finding no pre–post differences (p = 0.455) or training group differences (p = 0.705) (Singh et al., 2013). Three studies performed chair stands by number of repetitions in 30 seconds. Ray et al., (2012) found improvements from baseline to post test scores for both active groups, however, no differences were found between an exergaming and group fitness training group (p = 0.320). Sato et al., (2015) found significant differences in chair stand repetitions in an exergame group versus controls performing everyday activities (Mean Difference: 6.50, 95% CI 4.46 to 8.54, p <0.01). Nicholson et al., (2015) found no significant difference between exergame and everyday activities control groups.

	Exergaming			Controls				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Chow and Mann, (FRT)	1.9	6.2	10	0.7	5.4	10	21.9%	0.20 [−0.68, 1.08]
Pluchino et al., (FRT)	4.53	12.73	12	2.24	7.68	14	23.5%	0.22 [−0.56, 0.99]
Ray et al., (Sit and Reach Test)	−1.4	2.65	29	−0.1	2.52	40	27.8%	−0.50 [−0.98, −0.01]
Sato et al., (FRT)	4.52	4.18	29	0.44	3.97	28	26.9%	0.99 [0.43, 1.54]
Total (95% CI)			**80**			**92**	**100.0%**	**0.22 [−0.52, 0.96]**

Heterogeneity: $Tau^2 = 0.45$; $Chi^2 = 15.71$, $df = 3$ ($P = 0.001$); $I^2 = 81\%$
Test for overall effect: $Z = 0.58$ ($P = 0.56$)

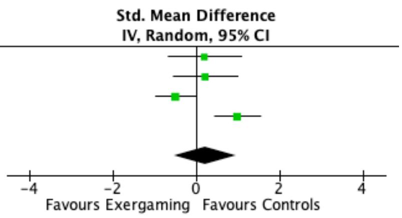

Figure 2.11 - Outcome measures using reaching tasks for exergaming vs. controls excluding non-RCTs. FRT = Functional Reach Test; Std. = standardised; IV = inverse variance; CI = confidence interval.

Study or Subgroup	Exergaming Mean	Exergaming SD	Exergaming Total	Controls Mean	Controls SD	Controls Total	Weight	Std. Mean Difference IV, Random, 95% CI
7.4.1 TImed up and go test								
Chow and Mann, (TUG)	−0.4	4.2	10	0.2	2.9	10	9.3%	−0.16 [−1.04, 0.72]
Lai et al., (TUG)	−2.3	4.87	30	0.4	6.27	30	18.0%	−0.47 [−0.99, 0.04]
Pluchino et al., (TUG)	0.47	2.39	12	0.06	1.69	14	11.2%	0.19 [−0.58, 0.97]
Ray et al., (8ftTUG)	−0.9	1.36	29	−0.6	1.4	40	19.1%	−0.21 [−0.69, 0.27]
Singh et al., (TUG)	−1.28	1.56	18	−2.34	1.62	18	13.4%	0.65 [−0.02, 1.32]
Subtotal (95% CI)			**99**			**112**	**70.9%**	**−0.04 [−0.43, 0.35]**
Heterogeneity: Tau² = 0.09; Chi² = 7.63, df = 4 (P = 0.11); I² = 48%								
Test for overall effect: Z = 0.20 (P = 0.84)								
7.4.2 One leg stance test								
Lai et al., (OLSEO)	16.14	37.87	30	5.13	43.25	30	18.1%	0.27 [−0.24, 0.78]
Pluchino et al., (OLSEO)	−2.42	27.19	12	8.5	14.97	14	10.9%	−0.49 [−1.28, 0.29]
Subtotal (95% CI)			**42**			**44**	**29.1%**	**−0.05 [−0.79, 0.68]**
Heterogeneity: Tau² = 0.18; Chi² = 2.54, df = 1 (P = 0.11); I² = 61%								
Test for overall effect: Z = 0.14 (P = 0.89)								
Total (95% CI)			**141**			**156**	**100.0%**	**−0.04 [−0.35, 0.28]**
Heterogeneity: Tau² = 0.07; Chi² = 10.42, df = 6 (P = 0.11); I² = 42%								
Test for overall effect: Z = 0.24 (P = 0.81)								
Test for subgroup differences: Chi² = 0.00, df = 1 (P = 0.98), I² = 0%								

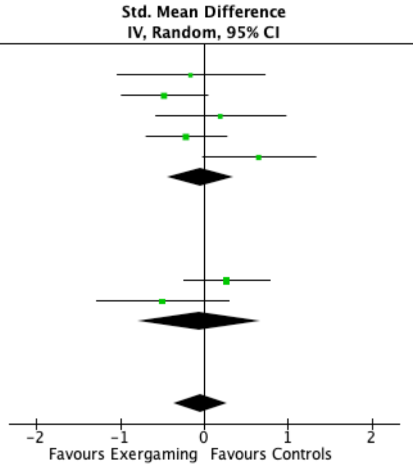

Figure 2.12 - Outcome measures using timed tasks for exergaming vs. controls excluding non-RCTs. TUG = Timed Up and Go; OLSEO = One Leg Stance Eyes Open; Std. = standardised; IV = inverse variance; CI = confidence interval.

Study or Subgroup	Exergaming Mean	Exergaming SD	Exergaming Total	Controls Mean	Controls SD	Controls Total	Weight	Std. Mean Difference IV, Random, 95% CI
7.5.1 Balance Confidence								
Merriman et al., (ABC)	11.61	17.43	38	4.92	21.45	38	22.0%	0.34 [−0.11, 0.79]
Whyatt et al., (ABC)	20.4	12.95	40	13.175	21.61	42	23.6%	0.40 [−0.04, 0.84]
Subtotal (95% CI)			**78**			**80**	**45.6%**	**0.37 [0.06, 0.68]**
Heterogeneity: Tau² = 0.00; Chi² = 0.04, df = 1 (P = 0.85); I² = 0%								
Test for overall effect: Z = 2.31 (P = 0.02)								
7.5.2 Fear of falling								
Lai et al., (MFES)	6.5	18.29	30	−0.44	20.03	30	17.3%	0.36 [−0.15, 0.87]
Merriman et al., (FES)	−3.84	10.13	38	−5.04	21.19	38	22.3%	0.07 [−0.38, 0.52]
Pluchino et al., (FES)	−2.8	7.48	12	−1	2.09	14	7.5%	−0.33 [−1.11, 0.45]
Pluchino et al., (FROP−COM)	1.7	3.96	12	−0.2	2.65	14	7.3%	0.56 [−0.23, 1.34]
Subtotal (95% CI)			**92**			**96**	**54.4%**	**0.17 [−0.13, 0.47]**
Heterogeneity: Tau² = 0.01; Chi² = 3.20, df = 3 (P = 0.36); I² = 6%								
Test for overall effect: Z = 1.12 (P = 0.26)								
Total (95% CI)			**170**			**176**	**100.0%**	**0.26 [0.05, 0.47]**
Heterogeneity: Tau² = 0.00; Chi² = 4.07, df = 5 (P = 0.54); I² = 0%								
Test for overall effect: Z = 2.42 (P = 0.02)								
Test for subgroup differences: Chi² = 0.80, df = 1 (P = 0.37), I² = 0%								

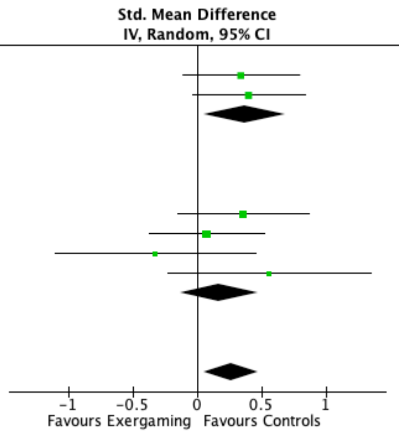

Figure 2.13 - Self-Report Measures of balance confidence and fear of falling for exergaming vs. controls excluding non-RCTs. FES = Falls Efficacy Scale; ABC = Activities-specific Balance Confidence Scale; FROP-COM = Falls Risk for Older People living in the Community; M = Modified; Std. = standardised; IV = inverse variance; CI = confidence interval.

2.2.3.4.3 Tertiary outcome measures

The instrumentation used to quantify postural control had many variations of measurement output which meant inclusion in the meta-analysis was not feasible. Pluchino et al., (2012) found no significant group x time interactions for any COP measures, and effect sizes were small ranging from n2 = .005 to .183. Lai et al., (2013) found a significant improvement in bipedal sway velocity (SV) of the COP with eyes open and closed ($p < 0.05$) and a trend of decrease in bipedal sway area (SA) of the COP for one of the groups performing the exergame phase of the intervention when compared to a 'no exercise' phase ($p < 0.05$). Singh et al., (2013) found no significant differences were observed between exergame and therapeutic balance exercise groups in overall performance index (OPI) of the COP ($F = 0.66$, $p = 0.42$). Park et al., (2015) found significant reductions in SV and sway length (SL) for both exergame and ball exercise groups ($p < 0.05$) and SL for the exergame group had a greater reduction than the ball exercise group ($p < 0.05$). Two trials used the Wii Balance Board with a custom designed game targeting static and dynamic balance measures based on time spent in specific target areas (static) and number of target areas obtained within a given time frame (dynamic) (Merriman et al., 2015, Whyatt et al., 2015). The COP was used to control the position visible on-screen, in real time. Merriman et al., (2015) found a significant interaction between test group and assessment ($F (1, 72) = 13.44$, $p < 0.001$) as following the exergame/control period, the exergame group performed significantly better than the control group ($p = 0.003$). Whyatt et al., (2015) found a pronounced improvement in the exergaming group for performance in levels of COP excursion. For dynamic balance, Merriman et al., (2015) found the exergame group significantly out-performing controls, as did Whyatt et al., (2015) (F (1, 80 = 39.54, p

< 0.001), $n^2 = 0.331$). Toulotte et al., (2012) calculated the percentage change of the COG on a Wii Balance Board™ and was pronounced for the exergaming group (61% change score) compared to an adapted physical activities (APA) group. It should also be noted that a third group (APA + exergaming) also improved significantly (44% change score). Ray et al., (2012) found no significant differences between exercise groups (Wii Fitness™ and Group fitness) for a Sensory Organisation Test (SOT). Pluchino et al. (2012) used a perturbation platform to quantify dynamic balance and found no significant group by time interactions for any dynamic posturography variables and effect sizes ranged from n2 = .003 to .041 for exergaming versus formal class-based exercise (Tai Chi and Standardized balance training program) suggesting exergaming is as effective as alternative balance programs.

2.2.4 Discussion

2.2.4.1 Effects of exergames on outcomes of the SFPC

The aim of this chapter was to systematically review the literature and perform meta-analysis on the effects of exergaming interventions on postural control outcomes for community-dwelling older adults. The evidence suggests that when comparing an exergaming intervention to traditional balance interventions and no intervention, it appears that exergaming had equal effects on training postural control outcomes relating to static stability, underlying motor systems, dynamic stability and anticipatory postural control but not for functional stability limits or sensory integration. Sub-group analysis by comparison group, revealed that exergaming had an equal effect on static stability, more of an effect on dynamic stability but less of an effect on underlying motor systems, functional stability limits, sensory integration and anticipatory postural control when compared to a traditional balance training intervention. Sub-group analysis also revealed that exergaming had more of an effect on underlying motor systems, dynamic stability and anticipatory postural control than participants not taking part in an intervention. Using the GRADE approach, the certainty of the evidence was low for all outcomes of the SFPC where data was available and reasons for judgements are outlined in Table 2.10. The RCTs and non-RCTs were assessed to be of low quality, high risk of bias with substantial statistical heterogeneity among the studies and there is strong indication for several outcomes indicating more robust RCTs are needed, especially for the outcomes not assessed in any of the studies included in this review. This is the first review, to the researcher's knowledge, to assess the effects of exergaming on outcomes associated with a framework that considers aspects of postural control from a theoretical basis and dictates that balance impairment may arise from a deficit in any given component of the framework (Horak, 2006, Sibley et al., 2015). This review not only indicates that there is a substantial lack of quality in current RCTs investigating the effects of exergames, but also indicates that exergaming interventions currently do not assess all the domains of postural control.

2.2.4.2 Limitations with the measures

The primary measures used in this systematic review consist of clinical balance assessments which were originally created to identify balance problems or the underlying cause of a problem to predict risk of falls and determine effectiveness of an intervention (Mancini and Horak, 2010). Healthy community dwelling older adults tend to have higher functioning capabilities and the 8 points of clinically significant change (Yelnik and Bonan, 2008) required in the BBS questions the validity of this assessment for already high functioning individuals and has shown ceiling effects in this regard (Pardasaney et al., 2012). The gait section of the Tinetti POMA is seldom used and has also shown ceiling effects (Yelnik and Bonan, 2008). The FRT, despite its purpose, has not been well correlated with centre of mass displacement due to availability of compensatory strategies to reach not accounted for in the test (Jonsson et al., 2003). The TUG also suffers the inability to detect early onset of impairment and the inability to understand if it is the gait or balance component of the scale that is affected may limit this form of measure. The use of rating scales, distance- based measures and timed tasks is practical and inexpensive for postural control assessment however, the ceiling effects observed in this population hinder the ability to predict any future concerns of healthy individuals, which is valuable information in order to understand changes in postural control. The use of questionnaires to evaluate self-perceived balance confidence and fear of falling are useful as they are nonintrusive and support the targeted direction of an intervention (Mancini and Horak, 2010). The ABC scale was developed on elderly outpatients and the confidence they perceived was based on a perceived need for a walking aid and personal assistance to ambulate outdoors (Powell and Myers, 1995). Balance evaluation measures have been previously rated in terms of the ability to measure different aspects of postural control and only one measure assessed all 6 aspects of postural control (Sibley et al., 2015). Adapted measures could discriminate higher functional balance ability in this specific population, which could result in a greater understanding of the effect of the intervention on postural control. The needs of higher functioning older adults are less dependent and more focused on higher levels of activities of daily living (Powell and Myers, 1995).

The range of equipment and output parameters relating to the COP characteristics of postural control requires consistency in order for instrumented outcome measures to be generalizable in the future. For example, comparing COP parameters using a force platform in Pluchino et al., (2012) trial with the percentage change of the COG measured on a Wii Balance Board in a trial by Toulotte et al., (2012). Several studies did report that participants tended to enjoy exergaming and increased motivation was observed but not measured in several trials. This concurs with several previous systematic reviews (Bleakley et al., 2015, Donath et al., 2016, Kümmel et al., 2016). A limitation to force plate postural control assessment is the inability to measure stepping action of dynamic balance, or indeed the dynamic balance accounted for during gait (Hwa-ann and Krebs, 1999). Individuals perform reactive and proactive postural control adjustments on a force platform (Piirtola and Era, 2006), but with the individual rooted to the platform, whether it is embedded or raised, not all components of the postural control system are challenged as the base of support remains in a static state. Recent research has shown the importance of stepping action for prevention of falls and improving postural control (Skjaeret et al., 2015). Postural control demands may be influenced by the complexity of the task and the environment in which the task is performed (Pardasaney et al., 2013). The use of a body worn accelerometer (BWA) to track postural control and gait in any environment has previously been demonstrated as part of the development of an instrumented physical capability assessment (ICAP) (Godfrey et al., 2015), yet was not used to quantify postural control in any of the trials in this review. The ability of BWA to track postural control over a period of time with standardised protocols (Lara et al., 2013) could enable accurate assessment of postural control in community environments for both healthy and fall prone individuals, with varying complexity of task and environmental demands. The potential for BWAs to be able to track higher functioning older individuals may eliminate the psychometric limitations seen in more traditional methods.

2.2.4.3 Effects categorised by outcome measure

The meta-analyses revealed that exergaming interventions were marginally less effective when compared to traditional balance interventions or no intervention. Although, after adjusting the meta-analyses to include only RCTs there was a shift in the direction of the effect for timed tasks towards exergames, which could be attributed to the removal of non-RCTs, although, the RCTs in this review were of low quality. Therefore, this is an assumption and must be considered lightly.

As outcome measures tend to replicate the therapeutic interventions to determine efficacy (Haigh et al., 2001), traditional balance training may bias the measures in their favour if they are closely matched in their movements. The BBS, for example, requires an individual to complete 14 tasks, which resemble typical daily activities such as sitting, standing, bending, reaching, weight-shifting and turning among other tasks (Berg, 1992). The 14 tasks administered in the BBS are of similar nature to the 14 functional activities administered in a standardised balance exercise programmes, used in an arm of a pilot RCT included in this systematic review (Pluchino et al., 2012). The 14 task-specific exercises challenged balance in almost a symmetrical way (sitting, standing, stepping, walking, weight-shifting and turning among other exercises). This is arguably reflected in the sub-group analysis of the rating scales meta-analysis forest plot. Interestingly, none of the studies in this review considered using the BESTest or the Mini-BESTest, which are both comprehensive scales used in clinical settings (Franchignoni et al., 2010, Horak et al., 2009, Chinsongkram et al., 2014, Godi et al., 2013, Tsang et al., 2013). This indicates that there could be some important information about postural control missing such as the capability to react to postural perturbations, to stand on a compliant or inclined surface, or to walk while performing a cognitive task (Franchignoni et al., 2010). Additionally, no studies in this review included the use of a BWM to assess postural control objectively. The use of a BWM may support the judgements of rating scale administrators, which would assist in eliminating clinician bias (Lara et al., 2013; Godfrey et al., 2015). Objective, non-biased data from BWMs may assist in augmenting clinical care and may contribute to a more individualised approach to treat postural imbalances in individuals where fall risks are multifactorial (Ramdhani et al., 2018; Horak 2006; Mancini et al., 2012).

Exergames, are mainly commercially available “off the shelf” games and the movements required to drive the gameplay are not underpinned by specific balance training research necessarily, although this warrants further investigation. Exergames were introduced to counter the lack of adherence to traditional balance training programmes (van Diest et al., 2013), and the young stage of exergaming research, which can be observed from the heterogeneity in intervention characteristics and the use of commercially available exergames could relate to the differences observed in the effect estimates of meta-analyses. Previous research that has accounted for movement symmetry between intervention arms, although not in an older cohort, found that exergames improved more so than traditional gym-based exercise when measured using anteroposterior and mediolateral range of the mean sway parameters (Barry et al., 2016).

None of the trials included in the current review performed follow-up measurements leaving a gap in the knowledge of long-term effects of exergaming on postural control. Previous systematic reviews have also reported similar findings (Laufer et al., 2014, Larsen et al., 2013), although reported on *p* values alone. The use of meta-analyses to report effect sizes are arguably more appropriate for intervention evaluation (Donath et al., 2016).

2.2.4.4 Strengths and limitations

This systematic review was conducted in line with the PRISMA statement. The effects of the current meta-analysis must be taken with caution due to the small number of trials pooled for analysis. Several meta-analyses failed to include the recommended number of studies at the outcome level due to lack of available data or the outcome not being measured. A suggested minimum number of studies to reasonably and consistently achieve powers from random-effects meta-analyses is five (Jackson and Turner, 2017). Statistical inferencing under the random-effects model is arguably more challenging and less worthwhile with fewer than five studies included. This was the case for sub-group analysis on several outcomes and forest plots pertaining to categorised outcome measures. Another limitation are several instances of double counting in the sub-group analysis during the meta-analysis for self-report outcomes of falls efficacy. The methods of assessment (BBS, TUG etc.) chosen to represent an outcome assessed several outcomes and may have been used more than once to represent more than one outcome. It is understood that this is a limitation of using scales that incorporate multiple components of postural control. Future research could explore the individual components of the scales to more accurately represent the outcome of interest within that scale and provide more precision of the effect estimate for that outcome and not for a parameter representing multiple outcomes. The high levels of bias and heterogeneity observed at the outcome level may not give a comprehensive picture of the effects of exergaming on postural control. Furthermore, this review reported on a mixture of healthy community dwelling individuals and some studies included sub-groups of fallers. Therefore, the outcomes of this review do not apply to those with pathological conditions and those at higher risks of falls. The inability to include the tertiary outcome measures in the meta-analysis at the outcome level indicates a gap in the contribution to outcomes from tertiary measure types. The vast array of technology-based postural control assessment, if collated into meta-analyses, could contribute to the direction of interventions to improve reactive postural control, verticality and cognitive influences outcomes of postural control. The studies included in the meta-analyses are of low quality and although we attempted to account for the differences, results should be interpreted carefully, particularly concerning selection bias and reporting bias.

2.3 Chapter Summary

The evidence suggests that exergaming interventions are still in the infancy of their development and heterogeneity observed in the meta-analyses suggest that theoretically underpinned development of an exergaming intervention is warranted. The high risk of bias as well as imprecision of the results may affect the capability to rely on the interpretations of the overall effect estimates included in this review. For several outcomes, exergames appears to be equally beneficial as traditional balance interventions, yet, the limitations in the quality of the trials and the imprecision of the effect estimate demand more high quality, robust RCTs with long periods of follow up in order to inform recommendations for exergaming interventions focusing on improving postural control at the population level. Outcome measures used to assess postural control hold psychometric limitations and balance measures used do not assess all aspect of postural control. Outcomes and associated measures that can differentiate balance deficits for older adults, in conjunction with a theoretical framework may aid the direction of exergaming interventions targeted at improving postural control for older adults. Adopting the use of technology based outcome measures, such as BWMs, may provide further insight with means to measure postural control more specifically to a population's ADLs, in the community and outside of the laboratory setting.

This systematic review was published in Maturitas, the official journal of the European Menopause and Andropause Society:

Tahmosybayat, R., Baker, K., Godfrey, A., Caplan, N. & Barry, G. 2017. A systematic review and meta-analysis of outcome measures to assess postural control in older adults who undertake exergaming. Maturitas, 98, 35-45. (Appendix A)

3.0 SYSTEMATIC REVIEW 2

3.1 Introduction

Chapter 2 of this thesis systematically explored exergaming intervention characteristics and the effects of exergaming to improve postural control outcomes for community-dwelling older adults, which included outcomes from a well-established theoretical framework, the Systems Framework for Postural Control (SFPC). The review and the meta-analyses conducted also documented the how categories of outcome measure may provide differences in the overall effect estimate of exergaming interventions. The previous chapter highlighted that not all outcomes are assessed in conjunction with the SFPC, in exergaming interventions. There is a gap in the knowledge of how exergaming interventions can improve the domains of postural control of reactive postural control, verticality and the influence of cognition on postural control performance. The review and meta-analysis provided insight into which outcomes are assessed, although the technology based outcomes could not be collated into meta-analyses. The next stage of reviewing the existing evidence would be to investigate the movements trained within exergaming interventions to understand which aspects of postural control are being trained and little is known about the movements that drive commercial and custom-made exergames. These systematic reviews play a crucial role in determining what outcomes are necessary to asses postural control with a coherent theoretical basis and whether exergaming is likely to be effective for older adults. The combination of the two reviews will contribute to the phase 1 developmental work of the Medical Research Councils (MRCs) framework for complex interventions to ensure clarity for the rationale of designing a suitable pilot intervention.

3.2 Movements of older adults during exergaming interventions that are associated with the Systems Framework for Postural Control: A systematic review

3.2.1 Introduction

3.2.1.1 Background

Falling is a consequential aspect of aging, neurological or musculoskeletal disease (Sterling et al., 2001, Rubenstein, 2006, Spaniolas et al., 2010, Gill et al., 2013). Exercise is a well-established means to reduce the risk of falling in older adults by significantly improving the systems that constitute balance, muscle strength, flexibility and endurance (Sherrington et al., 2011, Shumway-Cook et al., 1997). To maintain balance, the visual, vestibular and somatosensory systems cooperate to create postural and kinetic reactions to the immediate environment and over time these systems inevitably begin to decline (Borel and Alescio-Lautier, 2014). Balance based training has shown to improve the multitude of systems that constitutes the postural control system, which when impaired can be a strong predictor of falls for older adults (Agmon et al., 2014, Bleakley et al., 2015, Donath et al., 2016). A previous systematic review has presented evidence that exercise has statistically significant positive effects on balance when compared to usual activity for older adults through a variety of interventions (Howe et al., 2011). Most effective modes of exercise are training gait; balance; co-ordination and functional exercises; muscle strengthening and multiple exercises combined into the intervention (Howe et al., 2011). The quality of evidence for exercise interventions, however, remains mixed and it appears difficult to compare studies due to variation in use of outcome measures and modes of delivery, with a lack of a core set of measures available with few long-term effects of exercise interventions available (Howe et al., 2011). Exergaming (exercise-gaming) is showing to be as effective as alternative methods at improving postural control outcomes in community dwelling individuals (Bateni, 2012, van Diest et al., 2013). Current methods employed include group-based classes based on fall prevention training programmes such as the Otago exercise program (Campbell and Robertson, 2003) and the Falls Management Exercise programme (FaME) (Skelton and Dinan, 1999), which include key components such as balance, muscle-strengthening, flexibility and endurance (Gillespie et al., 2012) and well as Tai Chi and functional floor activities that train coping skills for confidence. The plethora of outcome measures used in exergaming interventions each hold individual limitations in higher functioning older adults, improvement retention has not been assessed longitudinally and the heterogeneity of intervention characteristics also make generalising outcomes problematic for exergaming based exercise interventions (Tahmosybayat et al., 2017). Movement characteristics of exergames have been previously explored and have focused on stepping exergames due to their natural occurrence during gait and their importance in the prevention of falls (Skjaeret-Maroni et al., 2016). The system setup used for exergames heavily influences the movements performed and therefore the movements trained during a given intervention. Although previous research has explored the importance of movement quality for designing future exergames for fall prevention, there is a need to utilise a framework based on postural control to fully understand the gaps in training for the underlying mechanisms. Outcome measures have been previously explored in a scoping review which identified components of postural control included in standardised balance measures based on the Systems Framework for Postural Control (SFPC) (Sibley et al., 2015). The SFPC was designed to detect underlying balance problems from a balance assessment tool "BESTest" developed and validated by Horak and colleagues (Horak et al., 2009). The ability to maintain equilibrium and postural orientation is reportedly context specific and the underlying physiological risk factors for balance are multifactorial, similarly to risk factors for falls (Horak, 2006). In any of the six components of the SFPC (Table 3.0), a constraint can come about from neurological, musculoskeletal or medicinal factors and subsequently increase the risk of falls and injuries from falls. Biomechanical limitations in the feet and the base of support (BoS) can affect the limits of stability due to reductions in size, strength, range and control of the feet or increases in pain. Inaccurate representation of the stability limits from the central nervous system (CNS) may result in postural instability in basal ganglia disorders such as Parkinson’s disease (Horak, 2006). A tilted or inaccurate internal representation of visual or postural verticality can result in an incorrect automated alignment with respect to gravity, which in turn increases instability, such as in individuals with unilateral vestibular loss (tilted) or individuals with hemi-neglect due to stroke (inaccurate) (Karnath et al., 2000). Older adults at risk of falls have shown to use movement strategies to maintain postural stability more at the hip than at the ankle and have used stepping actions due to the lack of ability to exert angle torque at the ankle as a preliminary strategy (Maki et al., 2000). There is also a lack of control of dynamics in older fallers in the form of larger than normal lateral excursions of the centre of mass (CoM) and more irregular foot placements. These limitations during gait or during postural transitions can lead to a trip, slip or fall depending on the context of the immediate external environment. Limitations in the ability to communicate sensory information in complex internal sensory environments can also put individuals at risk of falling in specific sensory contexts (stood in a well-lit room with a solid floor versus stood in a field at night) (Bugnariu and Fung, 2007). Individuals with Alzheimer's disease may prohibit the re-weighting of sensory dependence from the CNS even with a reliable peripheral sensory system (Horak, 2006). Cognitive processing is required for simple postural control strategies and increase with the complexity of the task with the addition of a secondary task (Huxhold et al., 2006). Neurological impairments can influence the ability to control posture and perform a secondary task and can lead to falls due to the lack of cognitive processing capabilities (Horak, 2006). The use of the SFPC to rate exergames may help target areas that are or are not being trained in exergaming interventions and may provide recommended games for specific components of the framework to subsequently tailor future training.

3.2.1.2 Aim of the review

Using the SFPC, this review will explore movement characteristics that train the postural control system during exergaming interventions. We hope to systematically address which movements are being trained and which system set-up best meets the components of the SFPC. This approach may inform design of exergames in the future by addressing the underlying mechanisms of postural control. The movements elicited during exergaming interventions may be dependent on the exergaming apparatus used, games played and movements required to drive the exergame. This review will contribute evidence to the development of a pilot intervention. The outcomes of the review will assist in choosing a console and exergame that is optimal for training postural control for community-dwelling older adults.

3.2.2 Methods

3.2.2.1 Study selection criteria, search strategy and quality assessment

The reporting of this systematic review was performed according to the PRISMA guidelines (Moher et al., 2009). Full details of the inclusion and exclusion criteria and the search strategy are provided within chapter 2, in the previous systematic review reporting intervention effects according to primary, secondary and tertiary postural control outcomes in exergaming interventions. Succinctly, randomized control trials (RCTs) and non-randomized control trials (non-RCTs) that assessed and reported postural control outcomes were included. Interventions were compared with traditional balance training modes and/or no exercise controls and included trials studied healthy community-dwelling older adults over 60 years who may or may not have fallen. Publications were all written in the English language from the UK, USA, the Netherlands, France, Malaysia, Hong Kong, Japan, Taiwan and South Korea. No publications were translated. Trials that studied individuals with balance impairments that prevented unassisted ambulation were excluded. Six electronic databases were searched for articles published between January 2000 and April 2016 using search terms related to exergaming, balance, exercise, falls and older adults for interventions based in clinical and community based settings. A further search was conducted to identify any additional publications from April 2016 to December 2017 as this review follows on from a previous systematic review. Additional publications were written in the English language from the USA, Singapore, Greece, Czech Republic and Brazil. None of the additional publications were translated. Title, abstract and full text screening were conducted by one reviewer (RT) and checked by another (GB). Reference lists of included trials were searched for additional publications.

3.2.2.2 Data extraction

Specific details pertaining to the interventions, populations, study methods and quality assessment from the original search exist in a previous publication and therefore was not repeatedly extracted. Search strategy, study characteristics and quality assessment for the additional publications from April 2016 to December 2017 were extracted. The extracted intervention features were as follows: exergame characteristics (console, game, scoring, difficulty /progression) movement characteristics elicited during exergame training based on 9 operational definitions (Sibley et al., 2015).

3.2.2.3 Data analysis

A rating scale was created based on nine operational definitions of the SFPC (Table 3.0). For each exergame and each component of the SFPC, movements were rated according to the following Likert scale: yes = 1, mostly = 0.75, somewhat = 0.5, less likely = 0.25 and no = 0. The movements required to drive each exergame were rated by two reviewers (RT and GB). GB is an expert in exergaming research and practice. In particular, exergaming to train postural control in older adults, sedentary and healthy populations, and development of exergaming for Parkinson's disease. RT has experience in postural control interventions in an ageing population and the implementation of novel exergaming systems. Once all movements were individually rated for each individual exergame, the mean (SD) was calculated for each publication. The reviewers discussed movement ratings together based on inter-rater reliability and re-evaluated for alterations in judgements. If the exergames used were not stated in the publication, the authors were contacted. With no response, movements could not be rated or scored for that publication.

Table 3.0 - Components of postural control operational definitions

Six components of SFPC		Operational Definitions	Does the game:
1. Biomechanical constraints: degrees of freedom, strength, limits of stability	1	Functional Stability	Test the ability to move the centre of mass as far as possible in the AP and ML directions within the base of support?
	2	Underlying Motor Systems	Test strength and coordination sufficiently through the physical activity of the game?
	3	Static Stability	Test the ability to maintain position of the centre of mass in unsupported stance when the base of the support does not change (May include wide stance, narrow, 1-legged stance, tandem, any standing condition)?
2. Orientation in space: perception of gravity, verticality	4	Verticality	Test the ability to orient appropriately with respect to gravity (e.g. evaluation of lean)?
3. Movement strategies: reactive,	5	Reactive Postural control	Test the ability to recover stability after an external perturbation to bring the centre

anticipatory, voluntary			of mass within the base of support through corrective movements (e.g. ankle, hip, and stepping strategies)?
	6	Anticipatory Postural Control	Test the ability to shift the centre of mass before a discrete voluntary movement (e.g. stepping-lifting leg, arm raise, head turn)?
4. Control of dynamics: gait, proactive	7	Dynamic Stability	Test the ability to exert ongoing control of centre of mass when the base of the support is changing (e.g. during gait and postural transitions)?
5. Sensory strategies: integration, reweighting	8	Sensory Integration	Test the ability to reweight sensory information (vision, vestibular, somatosensory) when input altered?
6. Cognitive processing: attention, learning	9	Cognitive influences	Test the ability to maintain stability while responding to commands during the task or attend to additional tasks (e.g. dual-tasking)?

AP = Anteroposterior, ML = Mediolateral

3.2.3 Results

3.2.3.1 Study selection criteria, search strategy and quality assessment

Results of the initial search strategy, evidence level and quality assessment please refer to the previous chapter. Results of the additional search strategy (Figure 8), evidence level (Table 3.1), quality assessment (Table 3.2, Table 3.3a and 3.3b) and additional study characteristics (Table 3.4) are presented below. All but one publication described the exergames used, whereby the author was contacted and failed to respond. Some, but not all exergames were described in that publication (Ray et al., 2012). Table 3.5 presents the characteristics of equipment and exergames used in the interventions.

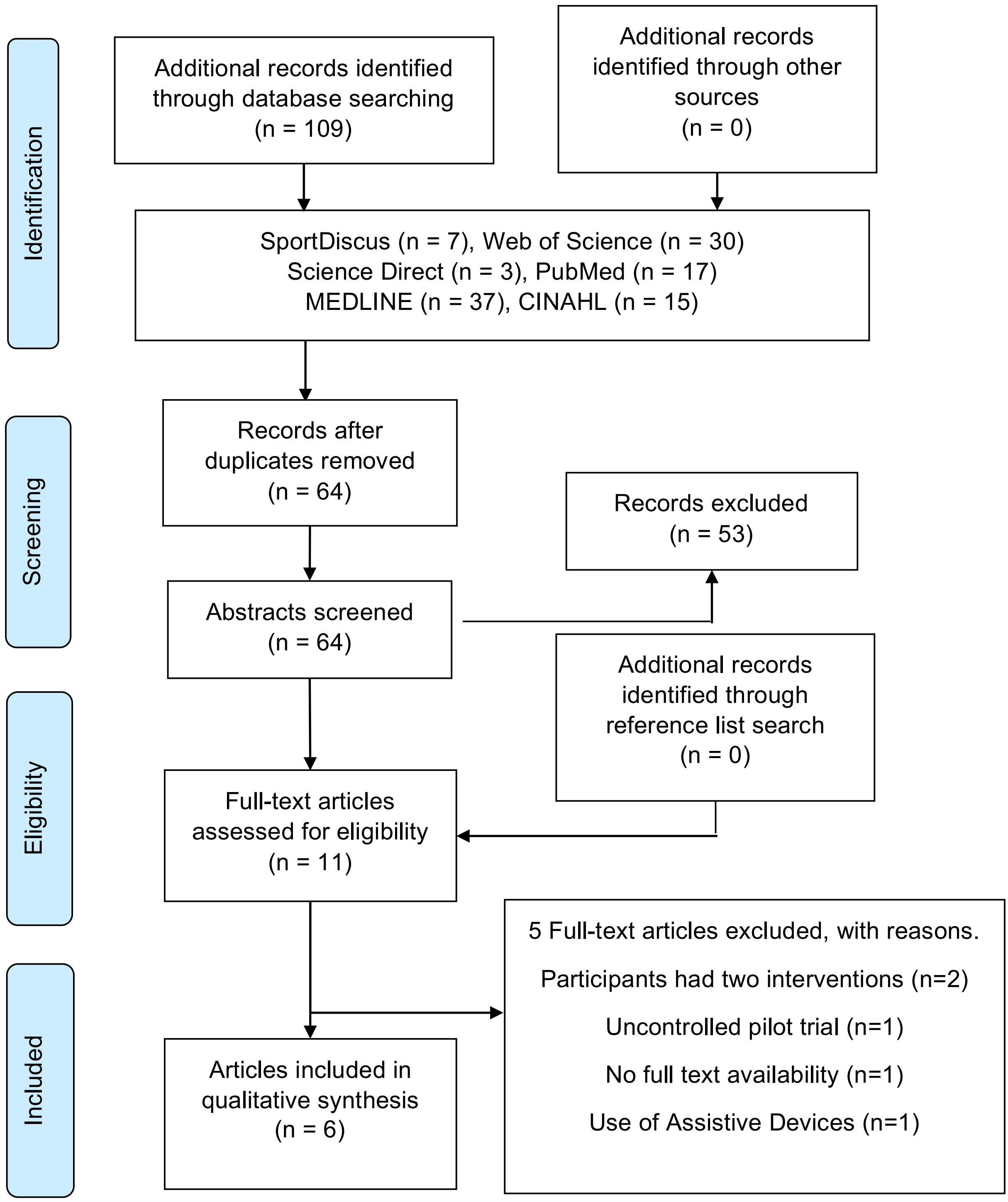

Figure 3.0 – Prisma study flow diagram of additional included publications

Table 3.1 - Results of Oxford Evidence Level of additional included articles

Author and Date	Hiearchy	Evidence Level
Bieryla. (2016)	RCT 2 arms, (PS)	2
Boon Chong and Yong Hao (2016)	RCT 2 arms	2
Konstantinidis., et al. (2016)	Two-group repeated measures	3
MaixnerovÁ., et al. (2017)	Two-group repeated measures	3
Monteiro-Junior., et al. (2017)	RCT 2 arms (PS)	2
Padala., et al. (2017)	RCT	2

Table 3.2 - Outcomes from PEDro scale quality assessment for additional articles

Author and Date	Eligibility Criteria	Random Allocation	Concealed allocation	Baseline Comparable	Blind Subject	Blind Therapist	Blind Assessor	Adequate Follow up	Intention to treat	Between group comparison	Point Estimates and Variability	Total
Bieryla. 2016	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	6
Boon Chong & Yong Hao. 2016	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Konstantinidis et al. 2016	Y	N	N	Y	Y	N	N	Y	N	Y	Y	5
Maixnerova et al. 2017	Y	N	N	N	Y	N	N	Y	N	Y	Y	4
Monteiro-Junior et al. 2017	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	7

Padala et al. 2017	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	8
Total	6	4	3	5	4	0	0	5	4	6	6	

Table 3.3a - Outcomes from custom designed quality assessment tool for additional articles

Author and Date	Research objectives clearly stated 1= yes, 0.5= yes lacking detail, 0=no	Study Design Clearly Stated 1= yes, 0.5= yes lacking detail, 0=no	Participant Characteristics Detailed Number, Age, Sex	Inclusion/ Exclusion Criteria Stated 1= yes, 0.5= yes lacking detail, 0=no	Outcome measures Described 1= yes 0 =no	Sample size justified 1= yes 0 =no
Bieryla. 2016	1	1	1	0.5	1	0
Boon Chong & Yong Hao. 2016	1	1	1	1	1	1
Konstantinidis et al., 2016	1	1	1	1	1	1
Maixnerova et al. 2017	1	0	1	1	1	0
Monteiro-Junior et al. 2017	1	1	1	1	1	1
Padala et al. 2017	1	1	1	1	1	1

Table 3.3b Continued…

Author and Date	Baseline and Post test data presented 1= yes, 0.5= yes lacking detail, 0=no	Randomization of groups explained 1= yes, 0.5= yes lacking detail, 0=no	location/settings described 1= yes 0 =no	Exergames instrumentation explained (console used, games used 1= yes, 0.5= yes lacking detail, 0=no	Is duration and intensity of intervention explained? 1= yes, 0.5= yes lacking detail, 0=no	Are the exergaming and if used, other exercise stated in detail? 1= yes, 0.5= yes lacking detail, 0=no	Was post intervention follow up used? 1= yes 0 =no
Bieryla. 2016	1	0	0	1	1	1	1
Boon Chong & Yong Hao. 2016	1	1	0	1	1	1	1
Konstantinidis et al. 2016	1	0	1	1	1	1	0
Maixnerova et al. 2017	1	0	0	0.5	0.5	0.5	1
Monteiro-Junior et al. 2017	1	0.5	1	1	1	1	1
Padala et al. 2017	1	1	1	1	1	1	1

Table 3.4 - Overview of the study design, sample characteristics, groups, intervention type and location for additional included studies

Author and Date	Study Design	Sample: Population; Sample Size (n); age, years (mean ± SD), M/F	Groups	Intervention & Follow up (Y/N)	Location/ Settings/ Supervision
Bieryla. 2016	RCT 2 arms, (PS)	Community-dwelling older adults, n=13, CG: 82.6 ± 6.9 years, KG: 82 ± 2.4 years), 3/10	KG (n=6), CG (n = 7)	KG: 3 x week 30 mins duration, 3 weeks. (N)	Supervised, Bucknell, USA
Boon Chong & Yong Hao. 2016	RCT 2 arms	Outpatient centre older adults, n=80 (43 his of falls), WAG: 70.5 ± 6.7 years, GEG: 69.8 ± 7.5 years 12/68.	WAG (n=40) + additional exercises , GymEx Group (n=40) + additional exercises	WAG: 60 mins per week, incl 20 mins Wii. GEG: 60 mins, incl 20 mins home	Satellite centre, General Hospital, Singapore

				exercise, 12 weeks. (Y)	
Konstantinidis et al., 2016	Two-group repeated measures	Community-dwelling older adults, n=232. IG: 69.08 ± 6.6 years, ACG: 69.98 ± 6.2 years, 48/184.	IG (n=116) received FFA intervention ACG (n=116) received cognitive training, identical in total duration and session intensity as well as grouping attributes.	60 mins, 5 x / week, 8 weeks.	Supervised by formal carers at a day care centre in Thessaloniki, Greece
MaixnerovÁ, Svoboda, XaverovÁ, DupalovÁ, & Lehnert, 2017	Two-group repeated measures	Community-dwelling older adults n=28, WFG: 81 ± 8 years, CG: 84 ± 11 years, 4/24.	WFG: (n=15), CG: (n=13).	20 mins, 2-3 x / week, 4 weeks.	Supervised, Olomouc, Czech Republic

Monteiro-Junior, R. S., et al. (2017).	RCT 2 arms (PS)	Institutionalised older adults n=29, GymEx: 85 ± 8 years, ACG: 86 ± 5 years, 6/12.	GymEx (n=15), ACG (n=14)	30-45 mins, 2 x / week, 12-16 sessions	Supervised, Fluminense, Brazil
Padala et al., 2017	RCT 2 arms	Community-dwelling adults n=30 (68.0 ± 6.7 years), 26/4	WFG: (n=15), BFG: (n=15)	45mins, 3 x / week, 8 weeks	Supervised, Exercise suite, Veteran Affairs Medical Centre, Arizona, USA

*RCT = Randomised Control Trial, *KG = Kinect Group, *CG = Control Group, *Mins = Minutes, *His = History, *GymEx = Gym Exercise, *WAG = WiiActive Group, *ACG = Active Control Group, *IG = Intervention Group, *FFA = Fit For All, *CEVR = Complex exercise with virtual reality, * BEVR = balance exercise with virtual reality, *WFG = Wii Fit Group, *BFG = Brain Fitness Group.

Table 3.5 - Characteristics of equipment and games used in exergaming interventions

Author and Date	Systems and apparatus used	Games	Game Duration	No. of Levels/ game	Scoring Procedure / level
Pluchino et al. 2012	Nintendo Wii Fit + Wii Balance Board	Soccer heading, ski slalom, ski jump, table tilt, tightrope walk, river bubble, penguin slide, snowboard slalom, lotus focus (Cool down game)	1st day: 7 minutes each, 2nd day: 5/8 games for 10 minutes each,	3 levels – Beginner, Professional & Expert	1-4 on each level
Ray et al. 2012	Nintendo Wii Sports and Fit, Wii Balance Board, Weighted Vest start at 2lbs and incremented 2 lbs / 2 weeks until 10lbs.	Wii Sports: Bowling + weighted Vest. Wii Boxing + weighted Vest. Wii Fit Plus games but no details of which games etc. Just stated balance and bodyweight shifting.	N/A	N/A	N/A

Toulotte et al. 2012	Nintendo Wii Fit + Wii Balance Board	Soccer heading, ski Jump, yoga, Ski Slalom, table tilt and tightrope walker.	G2: 1hr, G3: 30 minutes. Not stated how long per game.	3 levels - Beginner, Professional & Expert	1-4 on each level
Merriman et al. 2015	Laptop + Wii Balance Board used as interface device with Virtools 4.0 (Dassault Systems)	Custom Designed Games x 2. Apple Catch & Bubble Burst. Designed for older adults.	N/A	4 levels of difficulty	Apple Game: apple caught = 1 point, Bubble Pop: No. of bubbles popped per level
Sato et al. 2015	Microsoft Kinect	Apple game, tightrope standing, balloon popping, one-leg standing.	Apple Game, tight rope standing game: 90 secs. Balloon Popping Game: 40-90 secs.	Apple Game & Tight Rope: 3 levels of difficulty. Balloon popping game: 4 levels of difficulty.	N/A

Whyatt et al. 2015	Laptop + Wii Balance Board used as interface device with Virtools 4.0 (Dassault Systems), Zimmer frame for safety	Custom Designed Games x 4: Apple Catch, Bubble Pop, Avoid the Shark, and Smart Shrimp	N/A	4 levels of difficulty based on speed and position.	Continuous score throughout the games and were also presented with a final game score at the end of each level.
Lai et al. 2013	The Xavix Measured Step System ((XaviX port, one step mat)	N/A	N/A	N/A	Time standing, time exercising and total virtual distance travelled recorded during exercise.
Singh et al. 2013	Nintendo Wii Fit + Wii Balance Board	Ski Slalom, Table Tilt, Penguin Slide, Soccer Heading, Tight Rope Walk, Perfect 10 and Tilt City.	N/A	3 levels - Beginner, Professional & Expert	1-4 on each level

Chow and Mann. 2015	Xbox 360 Kinect	“Tiger Woods PGA Tour 13”	30-45 minutes/ game (10 holes/game)	10-hole gaming mode	N/A
Bieryla. 2016	Xbox 360 Kinect	Game 1: Your Shape-Fitness Evolved, Zen Sessions (Tai Chi and Yoga based exergame). Game 2: Kinect Adventures, 20,000 Leaks (Crab Crazy), Rally Ball (Peek A Boo) & Reflex Ridge (Collector)	15 minutes Game 1, 15 minutes Game 2.	N/A	N/A
Boon Chong & Yong Hao. 2016	Nintendo Wii + Wii Balance Board + Resistance bands	WiiActive (EA Sports Active): Run and Walk, Boxing, Inline skating, Biceps Curl, Triceps Kickbacks, Squats and Calf raise, Knee Crunch, Dancing, Shoulder Press, basketball, lunging, baseball, shoulder raises and tennis.	20 minutes per session	3 Levels for each individual game. Easy, Medium and Hard.	Number of repetitions/ goals or points scored.

Monteiro-Junior et al. 2017	Nintendo Wii controller + Wii balance board	Wii Fit Plus: Rowing Squat, Penguin Slide, Basic Run Plus. EA Sports Active: Bump and Set, Heavy Bag and Dance Basic 1 (Volleyball, Boxing & Dancing).	Performed each game once per session. 30 – 45 minutes per session.	Wii Fit Plus: 3 levels - Beginner, Professional & Expert. EA Sports Active: N/A	Wii Fit Plus: 1-4 on each level. EA Sports Active: N/A
Padala et al. 2017	Nintendo Wii + Wii balance board	Wii Fit: Half Moon, Torso Twist, Deep breathing, Ski slalom, penguin slide, tight rope walk, table tilt, balance bubble, Perfect 10	45 minutes	3 levels - Beginner, Professional & Expert	1-4 on each level
Konstantinidis et al. 2016	Fit For All: Nintendo Wii controller + Wii balance Board, Stationary mini-bike	Hiking, Cycling, Ski Jump, Arkanoid, Apple Tree, Fishing, Mini-golf, weightlifting and resistance gaming exercises	N/A	Each session has a difficulty level comprised of two components; intensity and gameplay difficulty. 4 levels from light	N/A

				exercise to intense physical exercise.
Maixnerova et al. 2017	Nintendo Wii Fit + Wii balance board	Penguin Slide, Table Tilt & Balance Bubble	Each game 5 minutes each	3 levels - Beginner, 1-4 on each level Professional & Expert
Nicholson et al. 2015	Nintendo Wii Fit + Wii balance board	Soccer heading, penguin slide, ski slalom, ski jump, table tilt, snowball fight, perfect 10, and tightrope walking	30 minutes	3 levels - Beginner, 1-4 on each level Professional & Expert
Park et al. 2015	Nintendo Wii Fit + Wii balance board	Soccer Heading, Snowboard Slalom, and Table Tilt	10 minutes on each game for a total of 30 minutes.	3 levels - Beginner, 1-4 on each level Professional & Expert
Tange et al. 2012	Nintendo Wii Fit + Wii balance board	Wii Fit, Wii Sports. Table Tilt is the only game mentioned	N/A	3 levels - Beginner, 1-4 on each level Professional & Expert

N/A = Not Applicable; G2 = group 2; G3 = group 3

3.2.3.2 Consoles and games

Of the eighteen publications, eleven used the Nintendo Wii™ with commercially available exergames (Wii Fit™, Wii Sports™ and/or EA Sports Active™) (Ray et al., 2012, Pluchino et al., 2012, Toulotte et al., 2012, Singh et al., 2013, Nicholson et al., 2015, Park et al., 2015, Tange et al., 2012, Boon Chong and Yong Hao, 2016, Monteiro-Junior et al., 2017, Padala et al., 2017, MaixnerovÁ et al., 2017). The most frequently used commercial exergame for the Wii Fit™ was "Table Tilt" used in eight publications, followed by; "Penguin Slide" in six publications. "Soccer Heading", "Ski Slalom" and "Tight Rope Walk" were all used in five publications. "Ski Jump" and "River Bubble" were used in three publications. Yoga based games on the Wii™ and "Perfect 10" were both used in two publications and the rest of the commercially available exergames were only used once in a given publication. Three publications utilised a custom design set up, whereby two used a Wii Balance Board™, a laptop computer with custom designed exergames for older adults and two exergames; "Apple Catch" and "Bubble Burst" (Merriman et al., 2015, Whyatt et al., 2015). "Avoid the Shark" and "Smart Shrimp" were also used in one of the publications. Another publication used a custom designed platform called "Fit For All" which utilised a Wii Nun chuck™ and a Wii Balance Board™ among other equipment, to navigate web-based custom designed exergames; "Hiking", "Cycling (Stationary mini-bike)", "Ski Jump", "Arkanoid", "Apple Tree", "Fishing" and "Mini-golf" (Konstantinidis et al., 2016). Three publications used a Microsoft Kinect™ camera, one with a custom designed set up with "Apple Game", "Tight Rope", "Balloon Pop" and "One Leg Standing" games (Sato et al., 2015), which seem to be closely related to the commercially available exergames of the Nintendo Wii Fit™. The other two Kinect™ based set ups used the

Xbox 360 with commercially available exergames; “Tiger Woods” (Chow and Mann, 2015), “Your Shape: Fitness Evolved” and “Kinect Adventures” (Bieryla, 2016). One publication utilised a Xavix Measured Step System (XMSS). The games available with the XMSS were; “Step Lively”, “Vigorous Step”, “Jackies Action Run”, “Dash” and “Reflex”. Information pertaining to exergames used in this publication was sourced elsewhere as no details of the games used were declared in the publication (Lai et al., 2013). The publications utilising Wii Sports™ did not de- scribe the games, duration, levels, scoring method or the movements necessary (Ray et al., 2012, Pluchino et al., 2012, Toulotte et al., 2012, Singh et al., 2013, Park et al., 2015, Tange et al., 2012).

3.2.3.3 Movement characteristics

Of the eighteen publications, eleven described the movements, four from custom designed exergames (Merriman et al., 2015, Whyatt et al., 2015, Konstantinidis et al., 2016, Sato et al., 2015) and seven from commercially available exergames (Pluchino et al., 2012, Park et al., 2015, Boon Chong and Yong Hao, 2016, Monteiro-Junior et al., 2017, Padala et al., 2017, Bieryla, 2016, Lai et al., 2013). It should be noted that some publications described the movements in more detail in the control group than in the exergaming group (Ray et al., 2012, Toulotte et al., 2012, Singh et al., 2013, Park et al., 2015). “Weight shifting”, “Side to side”, “Medio-lateral”, “anterior-posterior”, “COP displacement” “arm raise” and “leg raise” were the most commonly used terms to describe the movements to perform the exergames whereby more detail was given in the custom designed exergames which included the reasoning behind movements to drive the game. For this reason, an additional document was created to describe the internal game environment for most exergames and where possible, movements required to drive each exergame and scoring method. Where this was not provided, a hyperlink to a YouTube™ video is provided. This can be found in Appendix B.

3.2.3.4 Exergaming movements evaluated using the SFPC

The overall mean (SD) movement rating score for the eighteen included publications was 4.99 ± 1.27 of a possible 9 points, which when expressed as a percentage is 55 ± 8%. The overall mean scores expressed as a percentage for each operational definition of the SFPC for included publications were as follows: static stability (92%), cognitive influences (dual tasking) (92%), verticality (90%) and anticipatory postural control (84%). Functional stability (57%) and underlying motor systems (55%) were trained in just over half of the exergames. The least trained aspects of the SFPC were dynamic stability (29%), reactive postural control (0%) and sensory integration (0%). Some publications that used commercial "off the shelf" consoles and exergames or a custom set up with commercial apparatus (Wii Balance Board™) restricted training mainly to static stability due to a static BoS and this was reflected in the score. This was also the case for a publication that used a custom designed exergame with a Kinect™ camera, whereby the nature of the movements to drive each game required only static BoS and reaching tasks. The highest scoring publication used the commercially available "Your Shape- Fitness Evolved" and "Kinect Adventures" exergame which used a Kinect™ camera set up (Bieryla, 2016). With reference to the SFPC, this review has proposed that exergaming does encourage individuals to stand up (3), lean while standing (4), move upper limbs and turn heads (6) and dual-task while standing (9), to some extent move the body forwards, backwards and sideways (1), and coordinate movements (2) but hardly at all to kick, hop, jump or walk (7) and does not force a postural reaction from a physical force to the individual (5) nor mimic actual changes in sensory context (8). While exergames do train several components of the SFPC, there is also room for improvement. Researcher and games designer may find it beneficial for participants if incorporate the missing elements into exergame design or into the interventions alongside exergames to train more components of postural control. Results for movement ratings relative to the SFPC can be observed in Table 3.6.

Table 3.6 - Ratings for movements trained in Exergaming interventions relative to the Systems Framework for Postural Control

	Operational Definition of the Systems Framework for Postural Control									
Publication	1	2	3	4	5	6	7	8	9	Total/9
Pluchino et al., 2012 *										
Wii Fit -Soccer Heading	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	1.00	4.88
Ski Slalom	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	1.00	4.88
Ski Jump	0.50	0.63	1.00	1.00	0.00	0.00	0.00	0.00	1.00	4.13
Table Tilt	1.00	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	5.50
Tightrope Walk	0.50	0.50	1.00	1.00	0.00	1.00	0.63	0.00	1.00	5.63
River Bubble	1.00	0.25	1.00	1.00	0.00	1.00	0.25	0.00	1.00	5.50
Penguin Slide	0.50	0.25	1.00	1.00	0.00	0.75	0.25	0.00	1.00	4.75
Snowboard Slalom	0.50	0.25	1.00	1.00	0.00	1.00	0.00	0.00	1.00	4.75
Mean										5.00
SD										0.51
Ray et al., 2012 *, **										
Wii Sports - Bowling	0.00	0.13	1.00	0.63	0.00	0.00	0.13	0.00	0.63	2.50
Wii Sports - Boxing	0.25	0.38	1.00	0.63	0.00	0.75	0.13	0.00	0.75	3.88
Mean										3.19
SD										0.97
Toulotte et al., 2012 *										

Wii Fit -Soccer Heading	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	1.00	4.88
Ski Slalom	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	1.00	4.88
Ski Jump	0.50	0.63	1.00	1.00	0.00	0.00	0.00	0.00	1.00	4.13
Table Tilt	1.00	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	5.50
Tightrope Walk	0.50	0.50	1.00	1.00	0.00	1.00	0.63	0.00	1.00	5.63
Yoga	1.00	0.88	1.00	0.75	0.00	0.00	0.50	0.00	1.00	5.13
Mean										5.02
SD										0.54
Merriman et al., 2015 ***										
Apple Catch	0.50	0.25	1.00	1.00	0.00	1.00	0.00	0.00	0.88	4.63
Bubble Pop	1.00	0.38	1.00	1.00	0.00	1.00	0.38	0.00	0.88	5.64
Mean										5.13
SD										0.71
Sato et al., 2015 ****										
Apple Game	0.50	0.25	1.00	1.00	0.00	1.00	0.13	0.00	0.88	4.75
Tightrope Standing	1.00	0.25	1.00	1.00	0.00	1.00	0.25	0.00	0.88	5.38
Balloon Popping	0.25	0.63	1.00	1.00	0.00	1.00	0.38	0.00	0.88	5.14
One-leg Standing	0.25	0.75	1.00	0.88	0.00	1.00	0.38	0.00	1.00	5.26
Mean										5.13
SD										0.27
Whyatt et al., 2015 ***										
Apple Catch	0.50	0.25	1.00	1.00	0.00	1.00	0.13	0.00	1.00	4.88
Bubble Pop	1.00	0.38	1.00	1.00	0.00	1.00	0.25	0.00	1.00	5.63

Avoid the shark	1.00	0.50	1.00	1.00	0.00	1.00	0.25	0.00	1.00	5.75
Smart Shrimp	1.00	0.38	1.00	1.00	0.00	1.00	0.25	0.00	1.00	5.63
Mean										5.47
SD										0.40
Lai et al., 2013 *****										
XMSS - Step Lively	0.63	0.75	1.00	1.00	0.00	1.00	0.75	0.00	1.00	6.13
Vigorous Step	0.50	0.75	1.00	1.00	0.00	0.88	0.63	0.00	1.00	5.76
Jackie's Action Run	1.00	1.00	1.00	1.00	0.00	1.00	0.88	0.00	1.00	6.88
Dash	0.50	0.75	1.00	1.00	0.00	0.88	0.63	0.00	0.00	4.76
Reflex	0.25	0.63	1.00	1.00	0.00	1.00	0.75	0.00	1.00	5.63
Mean										5.83
SD										0.77
Singh et al., 2013 *										
Wii Fit -Soccer Heading	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	1.00	4.88
Ski Slalom	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	1.00	4.88
Table Tilt	1.00	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	5.50
Tightrope Walk	0.50	0.50	1.00	1.00	0.00	1.00	0.63	0.00	1.00	5.63
Penguin Slide	0.50	0.38	1.00	1.00	0.00	1.00	0.25	0.00	1.00	5.13
Perfect 10	0.75	0.38	1.00	1.00	0.00	1.00	0.25	0.00	1.00	5.38
Tilt City	0.50	0.25	1.00	1.00	0.00	1.00	0.13	0.00	1.00	4.88
Mean										5.18
SD										0.32
Chow and Mann, 2015 ****										

Tiger Woods PGA tour	0.25	0.38	1.00	1.00	0.00	0.50	0.13	0.00	0.50	3.76
Mean										3.76
SD										N/A
Boon Chong & Yong Hao, 2016 *										
EA Sports Active - Heavy Bag	0.25	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	4.75
Targets and Heavy bag (Boxing)	0.25	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	4.75
Targets	0.25	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	4.75
WBB Targets and Heavy Bag	0.25	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	4.75
Dance	0.50	0.25	1.00	1.00	0.00	1.00	1.00	0.00	1.00	5.75
WBB Dance	0.50	0.25	1.00	1.00	0.00	1.00	0.38	0.00	1.00	5.13
Kickups	0.50	0.88	1.00	1.00	0.00	1.00	1.00	0.00	1.00	6.38
Run, knees and kickups	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	7.00
Run	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	7.00
Upper body (resistance band) - Biceps curl	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	1.50
Shoulder press	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	1.50
Triceps Kickback	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	1.50
Upright Row	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	1.50
Bent over row	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	1.50

Shoulder raise - Front	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	1.50
Shoulder raise - Lateral	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	1.50
Lower body - Alternating Lunges	0.88	1.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	6.88
Alternating Side Lunges	0.63	1.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	6.63
Knee crunch	0.63	0.88	1.00	1.00	0.00	1.00	1.00	0.00	1.00	6.50
Squats	0.50	1.00	1.00	1.00	0.00	1.00	0.00	0.00	1.00	5.50
Squat holds	0.50	1.00	1.00	1.00	0.00	0.75	0.00	0.00	1.00	5.25
Sports - Shooting and passing (Basketball)	0.25	0.25	1.00	1.00	0.00	1.00	0.50	0.00	1.00	5.00
Inline Skating	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	7.00
Backcourt (Tennis)	0.50	0.25	1.00	1.00	0.00	1.00	0.00	0.00	1.00	4.75
WBB Tennis	0.50	0.25	1.00	1.00	0.00	1.00	0.00	0.00	1.00	4.75
Pitching and Batting (Baseball)	0.50	0.25	1.00	1.00	0.00	1.00	1.00	0.00	1.00	5.75
Mean										4.57
SD										2.05
Padala et al, 2017*										
Wii Fit - Ski Slalom	0.50	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	5.00
Table Tilt	1.00	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	5.50
Tightrope Walk	0.50	0.50	1.00	1.00	0.00	1.00	0.63	0.00	1.00	5.63
Penguin Slide	0.50	0.38	1.00	1.00	0.00	1.00	0.25	0.00	1.00	5.13
Perfect 10	0.75	0.38	1.00	1.00	0.00	1.00	0.25	0.00	1.00	5.38

River Bubble	1.00	0.25	1.00	1.00	0.00	1.00	0.25	0.00	1.00	5.50
Yoga	1.00	0.88	1.00	0.75	0.00	0.00	0.50	0.00	1.00	5.13
Mean										5.32
SD										0.24
Bieryla, 2016****										
YourShape - Fitness Evolved - Zen Session	1.00	0.88	1.00	0.50	0.00	0.00	0.25	0.00	1.00	4.63
Kinect Adventures - 20,000 Leaks	1.00	0.88	1.00	1.00	0.00	1.00	1.00	0.00	1.00	6.88
Rally Ball	1.00	0.88	1.00	1.00	0.00	1.00	1.00	0.00	1.00	6.88
Reflex Ridge	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	7.00
Mean										6.34
SD										1.15
Monteiro-Junior et al, 2017*										
Wii Fit - Rowing Squats	0.38	1.00	1.00	1.00	0.00	1.00	0.00	0.00	0.50	4.88
Basic run plus	0.50	1.00	1.00	1.00	0.00	1.00	0.50	0.00	1.00	6.00
Penguin Slide	0.50	0.38	1.00	1.00	0.00	1.00	0.25	0.00	1.00	5.13
EA Sports Active - Bump and Set (Volleyball)	0.50	0.75	1.00	1.00	0.00	1.00	0.50	0.00	1.00	5.75
Heavy Bag (Boxing)	0.25	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	4.75
Dance	0.63	0.38	1.00	1.00	0.00	1.00	1.00	0.00	1.00	6.00
Mean										5.42

SD										0.57
Nicholson et al., 2015 *										
Wii Fit -Soccer Heading	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	1.00	4.88
Ski Slalom	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	1.00	4.88
Ski Jump	0.50	0.50	1.00	1.00	0.00	0.00	0.00	0.00	1.00	4.00
Table Tilt	1.00	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	5.50
Tightrope Walk	0.50	0.50	1.00	1.00	0.00	1.00	0.63	0.00	1.00	5.63
Penguin Slide	0.50	0.38	1.00	1.00	0.00	1.00	0.25	0.00	1.00	5.13
Perfect 10	0.75	0.38	1.00	1.00	0.00	1.00	0.25	0.00	1.00	5.38
Snowball Fight	0.50	0.25	1.00	1.00	0.00	1.00	0.25	0.00	1.00	5.00
Mean										5.05
SD										0.51
Park et al., 2015 *										
Wii Fit -Soccer Heading	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	1.00	4.88
Table Tilt	1.00	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	5.50
Snowboard Slalom	0.50	0.38	1.00	1.00	0.00	1.00	0.13	0.00	1.00	5.01
Mean										5.13
SD										0.33
Konstantinidis et al., 2016***										
Fit for All - Hiking (Aerobic)	1.00	0.50	1.00	1.00	0.00	1.00	0.50	0.00	0.75	5.75

Cycling (Seated Aerobic))	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.75	1.25
Ski Jump	0.50	0.50	1.00	1.00	0.00	1.00	0.00	0.00	0.75	4.75
Arkanoid	0.50	0.50	1.00	1.00	0.00	1.00	0.00	0.00	0.75	4.75
Apple tree	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	0.75	4.63
Fishing	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	0.75	4.63
Mean										4.29
SD										1.55
Maixnerova et al. 2017*										
Wii Fit - Penguin Slide	0.50	0.38	1.00	1.00	0.00	1.00	0.25	0.00	1.00	5.13
River Bubble	1.00	0.25	1.00	1.00	0.00	1.00	0.25	0.00	1.00	5.50
Table Tilt	1.00	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	5.50
Mean										5.38
SD										0.21
Tange et al., 2012 *, **										
Wii Fit - Table Tilt	1.00	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	5.50
Wii Sports - Boxing	0.25	0.38	1.00	0.63	0.00	0.75	0.13	0.00	0.75	3.89
Mean										4.70
SD										1.14
Overall mean	0.57	0.55	0.92	0.90	0.00	0.84	0.29	0.00	0.92	4.99
Overall SD	0.31	0.26	0.27	0.28	0.00	0.35	0.35	0.00	0.18	1.27

*= Nintendo Wii + Balance Board + Wii Fit, **= Nintendo Wii + Wii Sports, ***= Laptop + Wii Balance Board, ****= Kinect, *****= other specialised technology.

3.3.4 Discussion

3.3.4.1 Main findings

To our knowledge, this work represents the first attempt to synthesize the literature on movements trained in exergaming interventions with respect to an established theoretical framework for postural control. The primary finding of this review is that of the included publications, no console and exergame setup trained all components of the SFPC. The consoles with a custom designed exergame or commercial exergames used “off the shelf” equipment. This makes it affordable yet not facilitative or tailored to the older individual which is well established (Skjaeret et al., 2016). The exergames used with the consoles were both commercially avail- able and custom designed for older adults, yet still failed to train all components of the SFPC. Specifically, the perception of standing up- right, reacting to a physical perturbation, control of dynamic balance such as postural transitions or dynamic balance during gait and essential sensory strategies to integrate or reweight information is not currently trained sufficiently no matter the set up or exergame used. These are all contributing components in multifactorial balance deficits and risk of falls (Horak, 2006). Identifying postural-based training needs can help aid the specificity of targeted interventions which are contributing factor to effective fall reduction programmes (Rubenstein, 2006).

The highest scoring set up was the Xbox 360™ and Kinect camera™ with exergames “Your Shape − Fitness Evolved” and “Kinect Adventures”, which are exergames that use whole body movements and stepping actions with various game components. It must be noted that the score was higher than that of other commercially available consoles due to the whole-body movements and stepping actions required to drive the game. This contributed to forward and sideways leaning as well as the control of balance with a changing BoS, which are also integral components of a balance training programme that has previously shown a 35% reduction in falls and falls related injury (Robertson et al., 2002). The raised platform of the Wii™ failed to utilise stepping actions outside the BoS, thus only training static and dynamic balance within the limits of stability. Training the ability to stand up is important for conducting daily activities and is known to show increasing difficulty with age (Tinetti and Ginter, 1988), but the likelihood of a fall increases once the BoS begins to change or when the limits of stability are compromised (Horak, 2006, Rogers and Mille, 2016). Individuals incapable of walking unsupported for long periods may benefit from the nature of standing exergames to strengthen the supporting muscles whilst simultaneously utilising attention to perform postural transitions. This form of dual-tasking may prove useful in rehabilitation programmes for individuals not able to perform more complex dual tasks and may aid improvements in lower limb strength (Yogev-Seligmann et al., 2008). The “Tightrope Walk” exergame on the Wii™ did involve a changing BoS via alternating stepping actions on the raised platform, which was the highest scoring exergame for the Wii™. A Kinect™ camera set up used a commercial golfing game and another with a custom designed exergame. This setup is equipment free and permits more movement, yet does not always train dynamic balance outside the BoS. This setup is promising in its ability to utilise whole body movements without restriction to a platform, but the selected exergame used must encompass the necessary stepping movements in its design in order to target that component of postural control. Step direction, size, length and speed all contribute to prevention of stumbling in everyday life alongside strengthening the lower limbs in older adults (Skjaeret et al., 2015). All publications in this review responded to additional tasks whilst trying to maintain and coordinate postural control (dual-tasking). Exergames prove to be beneficial in this regard (De Bruin et al., 2010). The magnitude of its benefit in conjunction with the SFPC remains unclear as the ability to differentiate the cognitive demand of each exergame was not explored in this review. It is known that an increase in cognitive processing occurs with physical and cognitive task complexity (Schoene et al., 2011). Cognitive demands of exergames must be introduced slowly and sparingly for individuals with slower cognitive function (Barry et al., 2014).

All exergames trained the ability to orient appropriately with respect to gravity as all participants remained standing for all movements in all exergames. Individuals that suffer from a tilted perception of visual vertical such as those that have suffered a stroke or individuals with lesion of the "vestibular cortex" in the brain (Karnath et al., 2000) may not benefit from this form of training as it unknown if changes occurred in their perception of vertical due to playing exergames.

Exergames, no matter the equipment used, did not train components of reactive postural control. Reactive postural control is initiated in response to an external perturbation (as low as within 100 milliseconds). The lack of a physical perturbation to an individual during gameplay means that corrective stepping actions are not strategically implemented. This fails to train the action of bringing the CoM back within the BoS once limits of stability are compromised, which is a fundamental mechanism of fall prevention (Horak, 2006). Multi-directional stepping actions are the required response and guidelines that can prompt corrective movements such as stepping behaviour during exergames have been proposed (Skjaeret et al., 2015). Individuals that perform stepping actions during exergames are responding to on-screen cues and not physical perturbations, however, it can be argued that the motor control for the postural response is being trained via stepping actions (De Bruin et al., 2010). Exergaming may help train the correct movement strategy selection and the magnitude of the response while responding to onscreen cues. Individuals have previously influenced postural responses with intention, expectation and experience (Horak, 2006). The intention to play, expectations of the next movement required in the game and the general experience of playing exergames could have an effect on these responses.

Dynamic stability was component of postural control minimally trained as there were no exergames that required a user to exert control of posture during gait, which would be impractical for the Kinect™ due to the spatial requirements within the range of the camera. Increasing dynamic contexts comes greater risk of falls and research has previously stated that balance training should be the primary focus in fall prevention programmes with walking as an additional component (Sherrington et al., 2011). It is not physically possible to train dynamic stability with a changing BoS with the Wii™ balance board set up. Consoles that used a raised platform only trained this component within the BoS. The Kinect™ allows for more free movement than the Wii™, but the chosen exergames failed to consider movements outside the BoS in their design due to movements required to drive the game being static in nature. Some exergames did elicit postural transitions (steps, hops, skips) which do require the BoS to change from one posture to another. Fall prone individuals tend to have greater variability in moving from one posture to another which is typically when a fall can occur (Horak, 2006).

Another component of postural control not trained was sensory integration which involves integrating and reweighting information to other alternative sensory inputs when one input is disturbed (visual, vestibular or somatosensory). The importance of being able to reweight sensory information from one sensory context to another is a key factor as falls can occur when there is a deficit in one of the senses (eyes, ears and body sensory feedback) (Horak, 2006). It is not currently practical or safe to train postural control via exergames in unsupervised environments that prohibit sensory inputs due to an increase in fall risk during training. However, with higher levels of cognitive task difficulty occurring during exergaming, there is higher domain resource competition in cognitive processing, which focuses attention on sensory integration (Huxhold et al., 2006) and it can be argued that by training at a higher level of cognitive function, attentional processes related to inhibitory control are engaged when sensory integration requirements are high (Redfern et al., 2001).

3.3.4.2 Strengths and weaknesses of the review

This review aimed to eliminate bias by following a strict protocol based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. There may have been a publication bias as mainly published articles were included in this review (all but one article) and as all articles were written in English, a language bias may have also been present. The population of focus in this review is limited to the healthier older adult over the age of 60 and cannot directly offer recommendations for those with more disabling conditions. The movements rated in this review were based on movements described in the included publications and where movements were not described, an additional document was created whereby information on the movements and game environments were explored and documented by the lead researcher (RT). This was created by searching and observing web-based videos of individuals playing with the exergames and observing the movements during the games. Although, a recommendation for future work would be to perform a meta-regression between the size of the treatment effect and the percentage score of the movement rating system, which could in some way test the theory that an exergame console and the associated games, or tailor made exergames that are more in keeping with the SFPC, would better assist improvements in postural control. It may also be of worth to perform a similar analysis for the comparison groups in exergaming interventions. This may provide more comprehensive information as to what is being trained in both the intervention groups and the comparison groups and may provide support for noticeable improvements in outcomes.

3.3.4.3 Implications for current best practice

Components of the SFPC should be considered when choosing consoles and designing exergames for older adults and exergames that track movement compliance should be used, where possible, and rated during exergame training to monitor correct form and distinguish capabilities of older individuals over the course of the intervention. Future exergaming interventions should closely match movements in the exergaming group with that of the control group (Barry et al., 2016). The movements should also be based on informed guidelines from current best practices and where possible incorporate movements that are theoretically linked to training deficits in postural control. An exergame platform (Mira Rehab™) currently exists that considers older adults in its design and incorporates movements based on well-established balance training programmes (Campbell and Robertson, 2003, Skelton et al., 2005) with a strong cognitive element, that are tailored to older adults interests, monitor progression and can be reviewed on a regular basis by a clinician via a digital platform of feedback. This exergame has been used for rehabilitation of balance outcomes in a pilot study with a small sample of participants (Verhoeven, 2017) and in a recent research study exploring motivational determinants of older adults exergame participation in assisted living facilities to improve physical function and reduce fall risk (Meekes and Stanmore, 2017). Older adults appear to respond well to exergames through enjoyment and perceived improvement in physical and mental health (Meekes and Stanmore, 2017).

3.4 Chapter summary

In accordance with the results of this systematic review, the evidence suggests that exergames may train static stability, anticipatory postural control, verticality and cognitive influences. The commercial and custom-made exergames included in this review may minimally train dynamic stability, functional stability limits and underlying motor systems and may not train reactive postural control and sensory integration. However, the ability to improve postural control outcomes with exergames is still possible if an appropriate selection of apparatus and design or choice of exergame is available. The recent availability of tailored exergames make the use of exergames promising for use with an older cohort. The evidence does suggest that a Kinect™ console may provide the opportunity to train more postural control outcomes outside the base of support than the commercially available Wii™ and its custom-made alternatives. A movement rating system is proposed in conjunction with an established theoretical framework. Not all elements of the framework are trained in exergaming interventions no matter the setup or the design of exergame. There are inherent limitations which remain a drawback of using exergames to train postural control. Certain components of postural control cannot be trained due to the unavailability of specialist equipment and spatial impracticalities that may compromise safety of older adults. Other elements demand external physical input to test reactions of the postural control system, which cannot be accounted for in digital games. Exergames that elicit stepping actions and whole-body movements outside the BoS better meet the requirements for training postural control according to this framework, which may be more optimally trained when using the Kinect™. However, a more precise exploration of the treatment effect and the percentage score of the movement rating system via mathematical modelling could test, more objectively, the theory that an exergame more in keeping with the SFPC would better assist improvements in postural control. The design or a selection of an exergame for use with older adults must consider as many of the trainable components of the SFPC in full by considering the full extent of the movement in each component of the framework. A recent exergame has been designed and is proposed for use in the pilot intervention.

This systematic review was also published in Maturitas, the official journal of the European Menopause and Andropause Society:

Tahmosybayat, R., Baker, K., Godfrey, A., Caplan, N. & Barry, G. 2018. Movements of older adults during exergaming interventions that are associated with the Systems Framework for Postural Control: A systematic review. Maturitas, 111, 90-99. (Appendix C)

4.0 STUDY 1 - FOCUS GROUP STUDY

4.1 Introduction

This chapter along with the two previous chapters together will contribute to the body of evidence that will assist the design of a pilot intervention to assess the feasibility of exergames to improve postural control for community-dwelling older adults. The previous two chapters have reviewed the existing evidence of exergaming intervention characteristics, the effect estimates and movement characteristics for outcomes associated with the Systems Framework for Postural control (SFPC). The existing evidence has provided support for the selection of a specific outcome measure as the primary measure for the pilot intervention and a tailored exergame for use with older adults. This chapter will contribute to the body of evidence by providing insight into the perceptions of two commercially available exergames (Kinect™ and Wii™) among adults of various ages and the shared perception of a group of older adults on a tailored exergame (Mira™). This chapter will highlight similarities and differences in perceptions to use exergames based on questions formed from a technology acceptance model and analysed using deductive thematic analysis.

4.2 An exploration of usability and acceptance (behavioural intention) of exergames in focus groups among healthy adults of various ages, including a trial of a tailored exergame (Mira™) for the older cohort.

4.2.1 Introduction

4.2.1.1 Background

Evidence Based Public Health (EBPH) systematically uses data, information, and scientific principles to enhance clinical care and population health through behaviour change interventions (Kohatsu et al., 2004). Similar to a model of patient-centred preventive health care, the definition of EBPH places a strong emphasis on the perspectives of community members, also known as a “population centred” approach, which highlights the importance of an affected population being at the forefront of decision making regarding public health interventions (Kohatsu et al., 2004). Assistance in the decision-making process involves accepting the methods to instigate change in behaviour interventions. The importance of the concept of acceptance to inform behaviour change has become an increasingly important theme in contemporary healthcare policy with the preferences of the public being considered in future planning of services and treatments. Government funded programmes dating back to 1996 such as INVOLVE, which is part of the National Institute for Health Research (NIHR), actively support public involvement in research into the development of treatments. Their core aim is to involve the public in research as an essential element to the process in order to better direct treatment (National Institute for Health Research, 2018). The public can be involved in the research process through participation in research studies but also through involvement in the planning stages of a research study through surveys, interviews, focus group discussions and pilot trials. The benefit of discussion between research participants on a specific set of issues, also known as a focus group discussion, is that the researcher can examine how knowledge and ideas develop and operate within a given context as opposed to tapping into individual biographies, which wouldn’t necessarily reflect multiple viewpoints of a population (Kitzinger, 1994). Involving the public in the process of developing an intervention could influence their levels of acceptance of the intervention through satisfaction. A recent review found a positive association between treatment satisfaction, patient compliance, adherence and persistence in that greater treatment satisfaction was associated with better compliance and improved persistence (longer attendance in a given study), and with lower regimen complexity or treatment burden (Barbosa et al., 2012). Integrating a sample of the target population in the research process of behaviour change interventions has shown to improve such outcomes seen as barriers to future participation, maintenance of therapy and continuity of change behaviours.

With an increase in the production and use of Information and Communication Technologies (ICTs), there is increased innovation promoting physical activity for public health (Peng et al., 2013, Althoff et al., 2016, Staiano and Calvert, 2011) and in assisting healthcare professionals in clinical settings (Gagnon et al., 2012). Exergames (exercise games) are not only used to promote physical activity (change behaviours) but can be used for more targeted training such as balance training, muscle strengthening, flexibility and endurance (van Diest et al., 2013). Balance training in particular has received attention over the last decade with the Nintendo Wii™ being the most used exergaming console (Allen, 2009, Hermes et al., 2010, Williams et al., 2010, Bateni, 2012, Toulotte et al., 2012, Bieryla and Dold, 2013, Laufer et al., 2014, Kinne et al., 2015, Tahmosybayat et al., 2017). Exergaming, as a means to train balance, is progressing with the use of more adaptable technologies such as the Xbox Kinect™, which has a gesture recognition camera that requires whole body movements or voice commands to interact with the console and does not require a handheld controller or a balance board (Tahmosybayat et al., 2018). Exergames are considered feasible and motivational when compared to traditional balance training therapy for previously injured competitive young male athletes (Vernadakis et al., 2014). The up-take of technology-based behaviour change interventions for older adults has also seen rapid growth to help manage or promote healthy behaviours and improve quality of life (Yardley et al., 2015). Technology such as “off the shelf” gadgets and computers are designed for use with younger and middle-aged adults, which has shown to have drawbacks for older adults use for this reason. This has seen an increased focus of technology acceptance in the design of behaviour change interventions for older adults, to overcome usage barriers and to understand user intentions and preferences of using technology (Rosser et al., 2009, Iliffe et al., 2010, Kennedy et al., 2012). By considering older adults perceptions on use of technology, researchers can develop behaviour change interventions to overcome barriers to use, intention and participation that empower older adults in the hope to promote healthy behaviours and add value to using technology for behaviour change (Oye et al., 2014).

A large number of theories and models have been designed to explore the acceptance and use of technologies, each with their own set of acceptance criteria for modelling users behavioural intentions (Venkatesh et al., 2003). Cognitive Dissonance Theory (CDT) explains how dissonance between cognition and reality change subsequent cognitions and behaviours (Bhattacherjee, 2001). Innovation Diffusion Theory (IDT) describes an innovation-decision process (Rogers and Shoemaker, 1971) that is a theoretical perspective on technology acceptance to analyse intent from the invention stage to its usage at both the individual and organizational level (Dillon and Morris, 1996). The Task-Technology Fit (TTF) model, within which it constitutes eight factors (quality, locatability, authorization, compatibility, ease of use/training, production timeliness, systems reliability, and relationship with users) holds that ICT has a more thorough impact on performance when capabilities match the users task (Goodhue and Thompson, 1995). Expectation Disconfirmation Theory (EDT) or Expectation Confirmation Theory (ECT) relates closely to the definition of CDT. It has four main constructs; expectations, performance, disconfirmation, and satisfaction (Oliver, 1980). This theory targets how and why user reactions change over time. The Theory of Reasoned Action (TRA) postulates that behavioural intention is divided into two conceptually distinctive beliefs: behavioural beliefs and normative beliefs (Fishbein and Ajzen, 1975). This theory suggests that individuals would use technology if they could see the added value associated with it. The Theory of Planned Behaviour (TPB), similar to the TRA, has a third determinant of intention, Perceived Behaviour Control (PCB). It is determined by the availability and importance of skills, resources and opportunities to achieve targeted outcomes (Kripanont, 2007). This theory postulates that by changing these three predictors, the intention that an individual will perform a desired action will also increase. Social Cognitive Theory (SCT) (Bandura, 1986) is based on the premise that environmental influences (social pressures, unique situational characteristics, cognitive factors, personality and demographic characteristics) are equally significant in predicting behaviour. The Technology Acceptance Model (TAM) was also developed based on the TRA, which better predicts and explains technology use (Davis, 1989) (Figure 4.0). The TAM posits that perceived usefulness and perceived ease of use better determine individual intention to use technology with behavioural intention directly relating to system use.

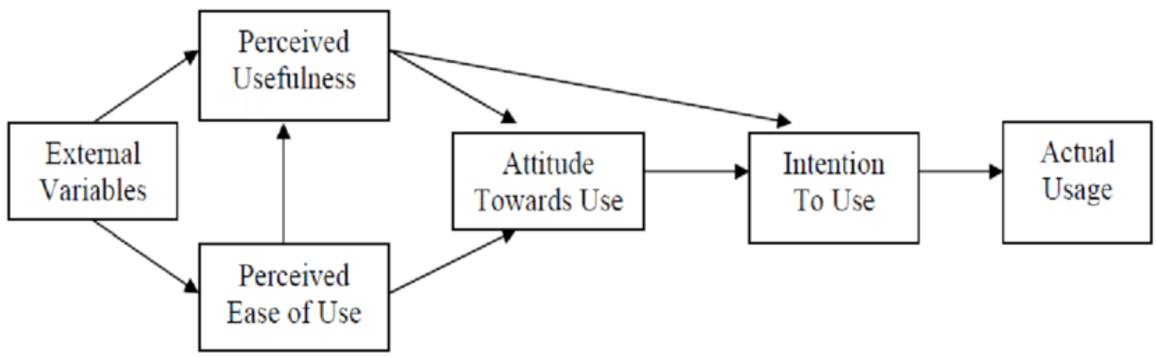

Figure 4.0 – The Technology Acceptance Model (Davis 1989)

The TAM construct of perceived ease of use is said to influence perceived usefulness with underlying links between the constructs such as attitudes, intentions, technology use behaviour, which was determined by theoretical underpinning from the TRA (Davis et al., 1989). The Model of PC Utilisation (MPCU) (Thompson et al., 1991) offers an alternate perspective to the TRA and the TPB in that this model predicts technology behaviour specifically for individual acceptance and for use with multiple technologies (Venkatesh et al., 2003). The Motivational Model and its two key constructs (intrinsic and extrinsic motivation) are based on Motivational Theory (Davis et al., 1992). It has been applied to understand and adopt use of new technologies. The TAM and the TPB have a combined model (C-TAM-TPB) (Taylor and Todd, 1995) with two added factors to better evaluate the important determinants of technology usage. The Unified Theory of Acceptance and Use of Technology (UTAUT) model has four core determinants of intention and usage (performance expectancy, effort expectancy, social influence and facilitating conditions) with up to four moderators of key relationships. This model theoretically determines the evolution of user acceptance and usage behaviour on technology over time (Venkatesh et al., 2003). The TRA, TPB, TAM and UTAUT are more popular technology acceptance models, used worldwide in a variety of settings. The TRA model is known to have limitations including a significant risk of confounding between attitudes and norms since attitudes can often be reframed as norms and vice versa. The TRA also assumes that when someone forms an intention to act, they will be free to act without limitation. The TPB aims to build on the limitations of the TRA, however, social norms scales are held from a poor psychometric standpoint may not influence behavioural intention. The TAM has compared favourably with TRA and TPB in that it is easier to gather information about perception of technology in a quick and inexpensive manner. The benefit of the TAM being parsimonious has restricted its ability to hold depth of information (Kripanont, 2007). The TAM combined with the situational variables of the UTAUT provide a more extensive picture on the acceptance and use of new technology. The UTAUT has been playing a key role in technology acceptance research and provides a solid base to explain why users accept or reject technology in a specific perspective. Venkatesh (2003) have compared the empirical data of eight models and have concluded that the UTAUT may be a more pragmatic approach to understanding behavioural intention with a higher explained variance (R^2) than in other models (R^2 = .69). Thus, the explanatory power of the UTAUT drastically outweighs older models and the UTAUT arguably provides a better understanding about the drivers of acceptance behaviours and the use of new technologies based on eight previous models.

Acceptance and usability of technology in exergaming interventions are generally self-reported secondary outcomes exploring participant feedback and session attendance. A scoping review revealed exergames are accepted by older adults in various living conditions and the use of gaming platforms differs amongst studies (Nawaz et al., 2016). Few studies have explored the acceptance and use of exergames for training balance from a unified view of intention and usage. Two randomised control trials reported use and acceptance outcomes of exergames from the UTAUT (Venkatesh et al., 2003) (Figure 4.1) and the Flow State Scale (FSS) (Jackson and Marsh, 1996) to gain an in-depth understanding of immersion during exergaming.

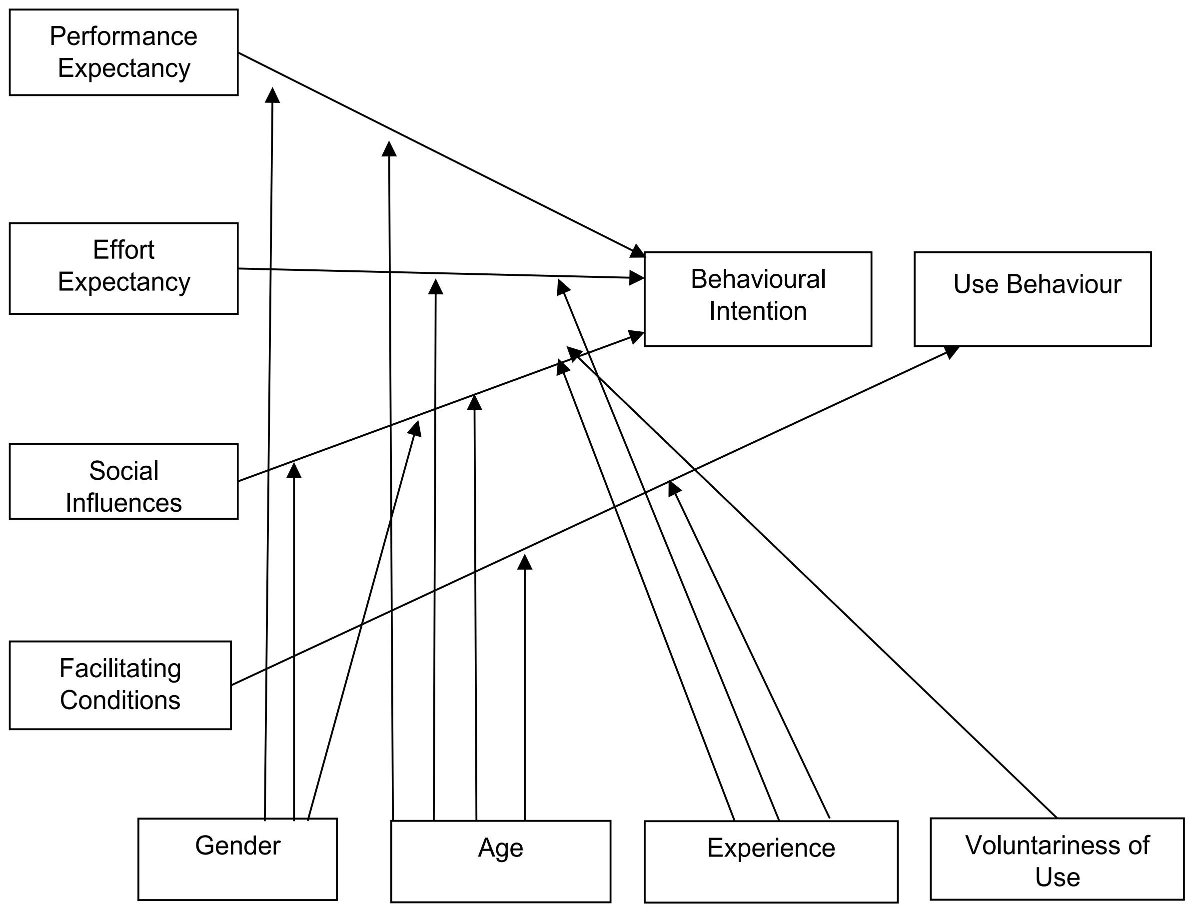

Figure 4.1 - The Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al. 2003)

One RCT had shown to improve balance related outcomes in individuals with Multiple Sclerosis equally to that of traditional therapy and found that “Wii Fit™” exergames were perceived as more effective at improving balance and easier to use, and the exergaming group maintained a higher state of flow experience during training (Robinson et al., 2015). Another RCT explored balance within the limits of stability (postural sway) comparing exergames and traditional gym-based exercise for healthy adults had shown greater improvements in mediolateral postural control, flow and UTAUT outcomes in a Kinect™-based exergaming group (Barry et al., 2016). No study has explored age-related differences in the perceptions of exergames to train balance with potential barriers to use to contribute to the design process of a targeted behaviour change intervention.

4.2.1.2 Aim

This chapter aimed to investigate the usability and acceptance of exergaming to train postural control and to explore any age-related differences or similarities in the perceptions of adults on using exergames to train balance. This chapter formed the final part of phase 1, the development of an exergaming intervention. The intent of this study was to understand the perceptions of adults of different ages towards commercially available consoles and exergames and their intent to use exergames to train balance based on the four key constructs of the UTAUT.

4.2.2 Methods

4.2.2.1 Study design

This study adopted a qualitative approach to explore how exergaming was perceived, used and accepted. An adapted version of the UTAUT model was used to formulate the focus group questions a priori. This would direct the focus group discussions in line with an established theory aimed at distinguishing acceptance and behavioural intention among different ages. The focus group discussion undergoes four major steps. These are 1) research design, 2) data collection, 3) analysis and 4) reporting of results (Morgan, 1996). A benefit of utilising focus group methodology to collect perspectives surrounding a research topic is to utilise the collective perceptions and meanings that lie behind the views (O Nyumba et al., 2018). The choice of focus group for this thesis was to explore behavioural intention of commercial exergames for balance. This approach formed part of the developmental work required for the a pilot intervention, as per the Medical Research Council (MRC) guidelines (Craig et al., 2008). This qualitative chapter will follow the format outlined in the Consolidated criteria for reporting qualitative research (COREQ) 32-item checklist (Tong et al., 2007) (Appendix D). Ethical Approval was granted by the Northumbria University Faculty of Health and Life Sciences ethics committee (REF: HLSRT060516) (Appendix E).

4.2.2.2 Research team and reflexivity

An experienced qualitative researcher (GW) led the first focus group with the lead researcher (RT) shadowing, RT led the second and third focus group and transcribed and analysed all focus group data. RT currently holds a BSc (Hons) and this work forms part of his PhD thesis. RT holds an interpretivist viewpoint in that his own background and knowledge may have influenced the way in which he views the research topic, which may be different to the reader of this thesis, the participants involved in the study and the other reviewers. The external realities of the focus group discussions do not necessarily reflect the internal realities of the participants involved in the focus groups, including RT. The meaning derived by RT is a function of the circumstances, the people involved and the broad interrelationships in the situations being researched. RT has had guidance from experienced researchers in the field of both qualitative and quantitative research in clinical contexts (GW, GB, KB, AG, NC). Leading up to and during this study, it is important to take into account reflexivity. Reflexivity has been simply defined as “an awareness of the researcher’s role in practice of research and the way this is influenced by the object of the research, enabling the way in which he or she affects both the research processes and outcomes” (Symon and Cassell, 2012). It is understood that there are complex relationships between the production of knowledge (epistemology), the processes undertaken to produce knowledge (methodology), and the involvement and impact of the knowledge of the researcher (ontology). Arguably, reflexivity is a tool that can be used to evaluate the role of a researcher during the research process in the hope to eradicate bias in research design and analysis (Symon and Cassell, 2012). It is indeed correct to assume a certain level of knowledge via the design and involvement of a researcher in a research study. Throughout the research process leading up to this study, RT had accumulated prior knowledge through conducting two systematic reviews that focused on exergames and older adults. Through reviewing the literature, RT may have preordained the desired outcomes from the focus groups for the older adults. RT had previously researched and experienced the equipment being used for this study. This may have influenced the way in which either console was portrayed by RT to the participants. The literature had already shown the benefits of using the Xbox Kinect™ over the Nintendo Wii™. Furthermore, RT had previously known that younger adults may be more inclined to prefer the more 'exciting' games over the 'older' exergames in the build-up to this study due to the relationships with those participants. RT was aware that there could be differences in acceptance and usability of exergames between different age groups and a benefit of this being apparent would fall in favour of the research aim. A confounding factor to this is that the questions of the focus group were a priori, however, the prompts may have been biased. RT may have also known the older adults in this study would prefer the use of a game more attuned to their capabilities based on the previous knowledge of the target audience for commercial exergames. Additionally, RT was aware of the Mira™ exergame prior to the study commencement which may have biased the viewpoint towards using this exergame in forthcoming feasibility intervention.

4.2.2.3 Relationship with participants

RT had previous relationships with most of the participants recruited in this study apart from the older cohort recruited for the third focus group. Participants in the first and second focus group were either fellow postgraduate students at the university or members of staff within the department. GW was the lead interviewer for the first focus group and had no prior relationships with the participants. RT acted as the data collector, outcome adjudicator and interpreter of the findings and discussed the outcomes with the research team. Participants were aware of RT research interests and the outcomes from this study being used to form part of a thesis. Participants were briefed on the nature of the research project prior to consenting to participate.

Participants were also aware that the focus groups were to gain insight into their experiences and perceptions after their brief trial with exergames. Therefore, it is understood that several biases exist pertaining to investigator involvement and prior relationships with several of the participants. The following assumptions are identified and stated to ensure transparent reporting of the findings:

- RT had prior relationships with several of the participants prior to the study commencement
- Participants also had previous relationships with each other in two out of three of the focus groups and it is understood that this could have biased the responses during the study

4.2.2.4 Participants

Thirteen individuals participated in three focus groups (age range 21-63 years). A voluntary sample was recruited via an email, which was sent to students and staff at Northumbria University and other individuals were contacted via an existing database. Participants were excluded if they self-reported neurological, musculoskeletal or orthopaedic conditions that affected activities of daily living or needed to use a walking aid during any activity. No participants were excluded from the study. All participants had prior experience of either the Kinect™ or the Wii™ in playing the games at least once in a social situation such as at family events at Christmas or a birthday. Participants were not classed as regular exergamers.

4.2.2.5 Data collection

4.2.2.5.1 Exergame trials

Participants arrived at the biomechanics laboratory at Northumbria University. All participants received an information sheet prior to the session and signed a consent form (Appendix F). The consoles were set up at opposite ends of a laboratory in areas divided by a blue screen (Figure 4.3). Participants were split over two smaller groups and designated 15 minutes on each console. Before trialling the exergames, participants were given a brief explanation for each of the pre-selected exergames. The exergames were selected based on the movements required to drive the game, which were chosen based on similarity to recommended movements to train balance (Campbell and Robertson, 2003, Skelton et al., 2005). The exergames available to play for the Kinect™ were from a commercial exergame “Shape Up™”. The following exergames were selected for use: “Piano Step (eye of the tiger song)”, “Squat me to the moon”, “Waterfall Jump”, “Stunt Run”, “Knee up splash” and “Volcano Skate”. The movements for the Kinect™ involved stepping, squatting, reaching, standing and hopping on one leg, side lunging and anteroposterior and mediolateral weight shifting. The exergames available to play for the Nintendo Wii™ were from the commercial exergame “Wii Fit™”. The exergames selected for use were: “Soccer Heading”, “Table Tilt”, “Tight Rope”, “Ski Slalom”, “Ski Jump”, “Balance bubble” and “Yoga”. The movements elicited in the Wii Fit™ exergames included anteroposterior and mediolateral weight shifting, walking on the spot, squatting and one leg standing. All movements for the Wii™ were conducted on a balance board, which prohibited any jumping movements or stepping outside of the balance board itself. Each exergame lasted one and a half minutes, which enabled individuals to trial between three and four exergames in the session. There was an onscreen tutorial for each exergame so participants could understand the necessary movements and objective of each exergame.

The third focus group (age range 60-63 years) trialled an additional exergame called Mira Rehab™ (Cantea et al., 2017). An exergame designed for use with older adults was developed with the older user at the centre of its design, yet utilised commercial equipment (Kinect™ sensor). The exergame follows a process, which incorporates the same process as visiting a physiotherapist in a clinic in that the diagnosis of the user is noted such as the area needing rehabilitation (strength, balance, coordination and flexibility), then the movements are selected and the exergames chosen based on each movement. Once all of the required exergames are selected, they can be added to a schedule bar at the bottom of the screen and the activity and rest length periods, difficulty and range of movement of the participant of each exergame can be set. The schedule can then be saved so it can be repeated. To begin the session, the participant is calibrated by the Kinect™ camera with instructions to move to the required position within the playing space (Figure 4.1).

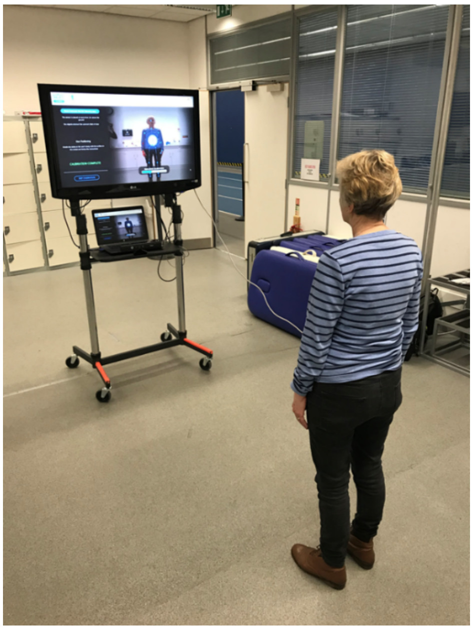

Figure 4.2 - Mira™ exergame participant calibration

Prior to each exergame, a virtual therapist gives a tutorial for each of the movements and another for the characteristics of the gameplay required (Figure 4.2).

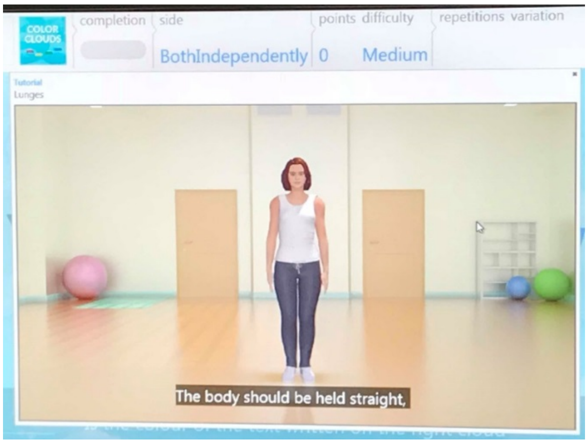

Figure 4.3 - Mira™ exergame virtual therapist instructing on specific movements to drive gameplay

Following the tutorials, the game immediately begins. We decided to trial this exergame after the second focus group to gain insight into perceptions of participants in the target age population group, which could prove as a potential exergame to be used in the main feasibility trial. Participants in this focus group trialled Mira™ for the same amount of time as the other two commercial exergames (15 minutes) (Figure 4.3).

Figure 4.4 - Participant trialling the “Grab” exergame within the Mira™ platform

4.2.2.5.2 Focus group discussions

Immediately following the trials, three focus groups (between 25 and 30 minutes each) were conducted. Participants were stratified based on age; focus group one (FG1) 23-29 years (n=6), focus group two (FG2) 48-49 years (n=2) and focus group three (FG3) 60-63 years (n=5). A Dictaphone (Sony Inc.) was used for the discussions. A focus group schedule was followed to ask open-ended questions regarding experiences, perceptions, usability and acceptance of the consoles, games, exergaming in general, and examined age-related differences between individuals (Table 4.0). The schedule was developed and adapted based on the UTAUT, which is a unified model one of technology acceptance and use and has 22 questions which are sub-divided into; performance expectancy (PE), effort expectancy (EE), social influences (SI), facilitating conditions (FC), self- efficacy (SE) and behaviour intention (BI) (Appendix G). The UTAUT model has previously shown good levels of reliability with internal consistency levels above 0.70 (Cronbach's alpha scores) (Venkatesh et al., 2003). GW led the first focus group and RT led the second and third groups. Throughout each focus group discussion, RT began by building rapport by creating a supportive and comfortable environment to promote honest and open dialogue. RT prompted participants that remained less active in conversation by relaying the open-ended questions to prevent a dominant speaker throughout the discussion. RT allowed the discussion to flow and was mindful of conversation drifting and used a series of prompts to direct the discussion back to the areas of interest, these are located in the transcripts. After the final question appeared to be exhausted in terms of responses, participants were thanked for their involvement in the study and offered the chance to receive feedback on their responses in notational form. No participants requested to have feedback following the discussions, no participants requested to leave the focus groups during any discussion, no external interruptions occurred during any focus group and no adverse events occurred during the trials of the exergames.

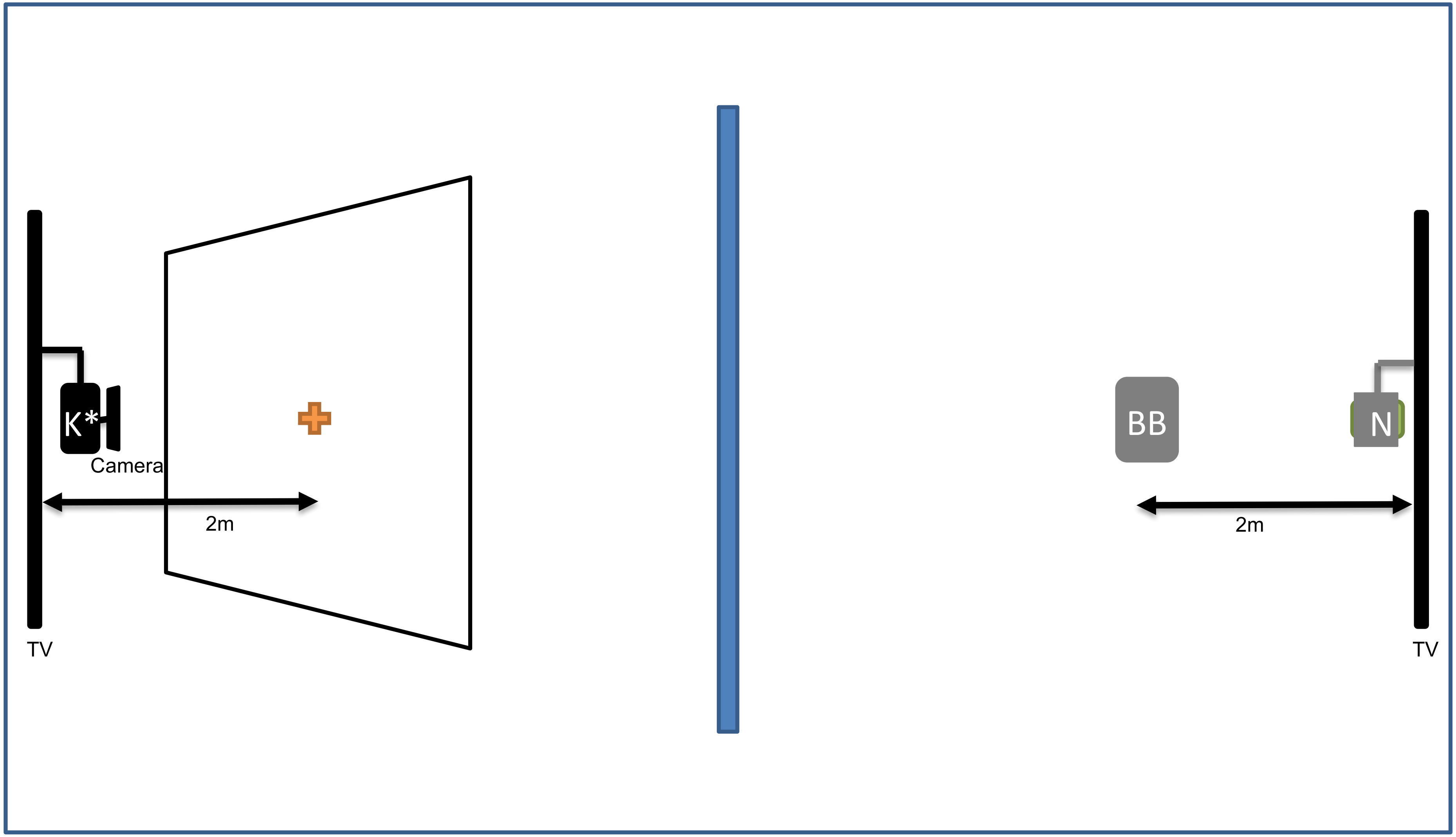

Figure 4.5 - Floor diagram of laboratory set up for exergame trial. BB = Balance Board™, N = Nintendo Wii™ console, K = Kinect™ camera and Xbox One™ console, * = Same location for the Mira™ exergame trial.

Table 4.0 - Focus group schedule based on constructs of the UTAUT

Questions:	
1.	What were your thoughts on Exergaming before this session?
2.	Which game did you favour the most? (Wii, Xbox Console + Kinect or Mira)
UTAUT - Performance Expectancy	
3	What are your thoughts on Exergaming in terms of benefitting your balance? On-screen vs actual. How did you fair with each game? Any favourite game?
UTAUT - Effort expectancy	
4	What did you think of the consoles? Easy to use/too complicated/boring? Which aspect were?
UTAUT - Attitudes towards the technology	
5	What would you change about Exergaming to make it/them more engaging? Profiles? Better picture? More onscreen instruction?
UTAUT - Social influence	
6	How do you think others would feel about you using Exergaming for training balance? Family? Friends? Someone with a balance impairment?
7	Who would you most likely play Exergames with?
UTAUT - Self-efficacy and Facilitative Conditions	
8	What changes would you make to the consoles to make you feel more able to use exergaming to train balance?
9	What are your perceptions on the safety of using either the consoles or perhaps exergaming in general?
UTAUT - Anxiety	
10	What are your thoughts on anxiety and exergaming?
UTAUT - Behavioural intention	
11	Would you like to use any of the consoles in particular again? Why? Why not?

Ending Question	
12	Is there anything else you would like to say about Exergaming and/or Balance Training?

UTAUT = Unified Theory of Acceptance and Use of Technology

4.2.2.6 Data analysis

As the project was restricted to time constraints of a PhD programme, the audio data from each focus group was transcribed by RT and themes were discussed with the research team. Data were uploaded onto a computer and transferred into Nvivo coding software (QSR International Pty Ltd). Data was analysed using deductive thematic analysis based on the constructs from the UTAUT model, following six stages (familiarisation; generating initial codes; searching themes; reviewing themes; defining and naming themes; writing up) (Braun and Clark, 2006). Focus group discussion questions were formed based on the subscales of the UTAUT model (PE, EE, SI, FC, SE and BI). Texts within the transcripts were coded by RT whereby participants reported on their personal and shared perceptions. Participants are identified by focus group number, participant number within each focus group and their age within the texts (FG1P01 aged 26 years). Quotations are presented within themes to illustrate findings. Participants did not request to be contacted regarding the findings of the study outcomes.

4.2.3 Results

To ensure the credibility and trustworthiness of the findings from this chapter, RT and GW reviewed all transcripts. Initial codes were generated by RT and discussed with GB and GW. Themes were formed independently by RT and discussed with GW and GB before finalising with the rest of the research team. Any interpretation ambiguities were discussed between the reviewers at each stage of the analysis. No major ambiguities were present between any of the reviewers for themes derived from the thematic analysis. The formulation of focus group questions based on the UTAUT model and prompts from RT helped ensure that the scope of the discussion did not drift far from the desired topic and the established UTAUT model added value to the credibility of the line of questioning during the focus groups. This may have also contributed to the lack of interpretation ambiguity between the researchers.

The degree to which the data from the present study was deemed credible arguably has an impact on the dependability or “repeatability” of the study. The planned and executed research design did not change, session were not rearranged and questions were not amended. Participants did not leave any of the focus groups which may also support the acceptance of the study design, although this is an assumption and must be taken lightly.

There was mixed experience and knowledge of exergaming. Ten participants had used the Nintendo Wii™ before the session, with eight participants having previously played the Wii™ games used in the session. One participant had used the Kinect™ before the session and no participants had previously played the Kinect™ games. Age-related differences in focus group discussions clearly emerged. It was evident that more of the younger users had previous knowledge and experience of exergaming than older participants. Despite previous experiences of these consoles and games, participants were asked to primarily discuss their experiences during the trial preceding the focus group. Reflecting components of the UTAUT scale, four themes were developed from the qualitative focus group data: attitudes toward the technology, consideration of balance and movement, ease of use, and social influence and exergaming. Additionally, we summarise the perceptions on the use of Mira™ by the final focus group separately. Full transcripts are available in Appendix H.

4.2.3.1 Attitudes toward the technology

Attitudes around enjoyment, immersion and motivation to play were developed. Generally, the Kinect™ was enjoyed more than the Wii™ for the freedom of movement, the continuity of gameplay and the opportunity to play as a group.

FG1P3 (aged 28) "Seems a bit outdated (Wii™) after you played the Kinect™ […] I think that one is (Kinect™) definitely group isn't it, and this (Wii™) would be better as an individual".

Age-related differences did however emerge with regards to immersion and motivation to play, with younger participants feeling more immersed when playing on the Kinect™ and more aware of their movements on the Wii™, especially due to the balance board. Older participants were more immersed on the Wii™ as opposed to the Kinect™ where they were *"a bit confused" (FG3P2, aged 63)*.

FG1P1 (aged 26) "I was just having too much fun dancing. I wasn't really paying attention with that one (Kinect™), whereas with this one (Wii™) I was a lot more like aware of my body and what I've got to do to move it".

Older participants found the complexity of the screen (object size and distribution) on the Kinect™ confusing which drew attention away from the movements, unwillingly.

They felt some exergames did not consider their vision, whereas they did not have to think about the movements during gameplay as much as on the Wii™, which they felt that the stationary nature was clearer and the screen was less busy.

FG2P2 (aged 49) "The Kinect™ is something giving you more confusing so you have to focus about the movement that you are doing or what is going on the screen. So, because it is the screen is too busy, you cannot be giving more attention to the movement […] but here (Wii™) it is more clear".

Participants felt less motivated playing on the Wii™ for different reasons. Some felt there was a lack of representation of the users whereby the emotional response from the virtual character did not represent the user's emotion and almost felt demotivating.

FG1P6 (aged 29) "I was just going to say it depends how easy it is to get the Wii™ character to change his emotion […] when you had a good experience there where you got to the end of the ropes, it was all bing bing bing bing but if it takes you ages, what's the likelihood of you giving up in that period of time?".

Participants also felt that the movements conducted were misrepresented on the Wii™ Balance Board which demotivated them.

FG2P1 (aged 49) "The thing is, you know as I was saying I do yoga and the balance that it was picking up on there from me was terrible. Well it was really coming up as though it wasn't balanced at all […] to me it's not an accurate assessment of balance on there at all".

Participants of a younger age were not necessarily demotivated because of the Wii™. They felt that progression with the Wii™ was the motivating aspect, which was deemed more task based as opposed to fun on the Kinect™.

FG1P1 (aged 26) "Like you said I could obviously whatever, like be because of the task itself could be doing more balance but I find with that (Wii™) I'm focusing a lot more because there is a board for me to stay on".

4.2.3.2 Consideration of balance and movement

Participants felt the Wii™ was more for static balance training and the Kinect™ more so for dynamic balance training. They felt the Kinect™ demanded more unnoticed balance skills whereas they were aware of their movements on the Wii™ because of the balance board restrictions and the sensitivity of movement during gameplay.

FG1P6 (aged 29) "You're stood on the board, and that's the only place, so everything is, like, feet up movement if that makes sense. Whereas with that (Kinect™), like, [moving] around skating and doing all sorts of weird movements […] you're much more animated on that than you are there".

Participants also considered movement restrictions as they felt that although the Kinect™ has free movement, this would not be appropriate in the home or small spaces due to spatial requirements and the nature of the movements to drive gameplay.

FG2P1 (aged 49) "Especially the Kinect™ if you were using that at home you'd have to move furniture that was in the […] move the coffee table or the settee that bit further back to be able to make sure that you could do it safely and not hurt yourself".

4.2.3.3 Ease of use

Initially, participants of all ages considered the Wii™ was more usable than the Kinect™.

FG1P3 (aged 28) “It’s a little bit easier I think (Wii™) but that just might be because I’ve played that a few times more often than I’ve played this (Kinect™).

Younger participants felt that the Wii™ controllers were difficult to use *“if you’re a bit shaky” (FG1P2, aged 31)*, the Wii™ balance board could be a trip hazard in the home environment but wouldn’t stop them playing with the console.

Participants felt that the Kinect™ was *“more accurate” (FG2P2, aged 49)* due to the technological advancement (gesture recognition software replacing a balance board) and demanded more accurate movements than on the Wii™. Yet, there was general consensus across all age groups that the Kinect™ posed problems in gameplay due to the lack of instructions during the game and the congestion of the screen, and it was agreed by younger participants that older adults would struggle with this issue, which ultimately was the case. This can be attributed to the game and not the console.

Younger participants got used to the congested screen and how to drive the gameplay but older adults felt confused and didn’t know what to expect or how to improve. This ultimately made using the Kinect™ more difficult. Older adults felt that the graphics and speed of gameplay was not tailored to their population and could be even more dangerous for frailer individuals in care homes.

FG3P1 (aged 62) “that one (Kinect™) the schematics weren't all that good but that’s probably my eyesight or something like that.”

FG3P3 (aged 63) “The Kinect™ I don't think would be appropriate in like a care home because it’s too fast”.

4.2.3.4 Social influence and exergaming

Participants would tend to play with others on occasions where everyone is in a home environment. This implies the consensus that others expect to see the participants use the consoles at social occasions and more so for fun than to train balance, however, some also described social influence that would discourage play at home.

FG1P6 (aged 29) "My elderly neighbours would not appreciate me bouncing up and down on the Kinect™ on the first floor of a flat".

Younger participants stated that playing with strangers would increase anxiety initially, especially if there are higher performing participants in the same group, however, participants in the oldest group found no anxieties towards playing with strangers, family or friends and did not mind seeing themselves onscreen.

FG3P2 (aged 63) "I think at our age you're not really bothered anymore, you don't care. You're not bothered about making a fool of yourself".

Competitiveness was a social aspect discussed throughout. All participants found the Kinect™ *"more competitive than the Wii™" (FG1P4, aged 23)* due to having a two-player function.

FG3P1 (aged 62) "I think people are still competitive doesn't matter how old they get".

Older participants preferred the social aspects of the Kinect™ due to the competitive nature of the dual player gameplay, making it more fun than the Wii™.

FG3P3 (aged 63) "I liked the competition. I like the competition that you could have on that [Kinect™]".

Interestingly, the older participants had pointed out that playing alone on the Wii™ could be demotivating which coincides with playing as a group on the Kinect™.

FG3P3 (aged 63) "you may lose motivation if you are just doing it against yourself. You get to a point where I hit thirty thousand points … I'm bored".

Younger participants felt more anxious with the Kinect™ than the Wii™ in part. Anxiety was associated with self-consciousness with seeing oneself on screen or performing movements in front of a group of people.

FG2P1 (aged 49) "You are more self-conscious of the Kinect™ because your figure is on the screen initially […] but you get over that".

It appears that having an objective, a social or competitive nature to a game is important in motivating individuals to play, and this does not dissipate with age, however, younger individuals do feel anxious when playing with others.

4.2.3.5 Perceptions of a tailored exergame (Mira™)

Participants in FG3 also sampled Mira™, an exergame designed for use with older adults, and found the exergame similar to the Wii™ but more specialised to training specific aspects of balance. They felt that Mira™ drives the correct movements for rehabilitation with more instant feedback and more tailoring to their needs.

FG3P4 "It (Mira™) was specialising in one area wasn't it. If you, you need to exercise your hip you could find an exercise on there".

They felt that although similar to the Wii™ in nature, with no balance board there was less restriction and less worry about falling. They felt that Mira™ also tracked movement, which could help assist the participant during training and was like having a personal physiotherapist. Participants went on to state that Mira™ is a much needed tool due to the long waiting list of the NHS appointments.

FG3P3 "Well if it's aimed at physiotherapy it drive the right behaviours because you've... you're getting instant feedback and you're also getting presumably feedback from the physio. You to do it more often less often or stretch more. As things go on you can tailor it so whatever you are flexing you can flex more […] the quicker that comes out the better because if you ever want to make a physio appointment... make it before you break something... it's about 9 weeks".

Participants felt that using Mira™ is the option if an individual is recovering from injury or is unbalanced and playing the Wii™ on their own or with friends for fun.

FG3P4 "It was specialising in one area wasn't it. If you, you need to exercise your hip you could find an exercise on there (Mira™) […] that neck one where you had to keep the rest straight and just move your neck. So if that was right with the neck one it was very accurate because it wouldn't register unless you were just moving".

FG3P5 "Well it depends if you were doing, if you'd been told you had to do some rehabilitation then maybe that one over there (Mira™)".

FG3P3 "Anybody who was injured would probably veer toward that one (Mira™) […] to specify what your injury is I suppose".

They would use Mira™ if they had an impairment or an injury as they felt it drove the correct behaviours and monitored progression and movement compliance.

FG3P3 "Well if it's aimed at physiotherapy it will drive the right behaviours because you're getting your instant feedback and you do it more often less often or stretch more. As things go on you can tailor it so whatever you are flexing you can flex more".

FG3P1 "I think that one's more for mentoring (Mira™)".

Participants found Mira™ of similar nature to the Wii™ due to the single player function and less competitive with others, yet still competitive and was more rehabilitation oriented. Participants did not mention factors relating to motivation for the Mira™ exergame, although similar to the Wii™ in nature (single player, slower game speed), the Mira™ exergame still allows free movement with no equipment needed to drive gameplay.

4.2.4 Discussion

This chapter aimed to investigate the usability and acceptance of exergaming to train postural control and to explore any age-related differences or similarities in the perceptions of adults on using exergames to train balance. This chapter formed the final part of phase 1 of the development of an exergaming intervention. The intent of this study was to understand the perceptions of adults of different ages towards commercially available consoles and exergames and their intent to use exergames to train balance based on the four key constructs of the UTAUT. Four themes emerged from the data and demonstrated similarities and differences across the age groups: attitudes toward the technology, consideration of balance and movement, ease of use, and social influence and exergaming.

4.2.4.1 Findings in relation to the literature

Exergaming is perceived as being beneficial and accepted, which concurs with the existing literature (Williams et al., 2010, Vernadakis et al., 2014, Nawaz et al., 2016, Barry et al., 2016, Meldrum et al., 2012, Wuest et al., 2014, Vaziri et al., 2016, Glännfjord et al., 2017). Exergaming on the whole, was generally accepted, both consoles types were enjoyed and perceived as socially connecting. However, age-related differences emerged with differences arising between the consoles in attitudes toward both consoles, balance and movement, and ease of use.

Younger adults did not prefer exergaming as a method of balance training. The Wii™, more focused on static balance, was observed to be outdated for younger people and they would rather perform exercises and balance training in other forms, such as gym class, outdoors, and yoga. This contrasts with previous literature whereby previously injured competitive male athletes' (15 to 17 years) intentions to participate in exergaming were significantly higher than intention to participate in generic physical activity (Garn et al., 2012). This also contrasts with a RCT whereby young to middle aged healthy adults (21 to 47 years) in an exergaming (Kinect™) group showed higher levels of technology acceptance to train balance (Barry et al., 2016).

Adults, whether young or old, favour the opportunity to use exergames to train balance more so with others rather than alone. It appears that with age, the decline in physical capabilities does not diminish the competitive nature and it is necessary to challenge cognitive abilities such as reaction time, dual tasking, attention, concentration and decision making, especially for individuals who are beyond the age of retirement (Bonsang et al., 2012, Willis, 1996). This coincides with other empirical evidence in that exergames must be usable, yet challenging in order to maintain continued use of these consoles (Nawaz et al., 2016, Harrington et al., 2015).

Participants young and old found that screen complexity (on-screen object size, and instructions) played an important part in deciding on use of exergames, however, some age-related differences were evident. Similar to recommendations from other research (Nawaz et al., 2016, Wuest et al., 2014), all participants found instructions for the Wii™ to be clearer and older adults preferred the pace of the commercial gameplay on "Wii Fit™" when compared to "Shape Up™" on the Kinect™. It must be stressed that these drawbacks are not barriers to using the console, but barriers to using the exergames, which may indirectly impact console use depending upon availability of other games. Contrastingly, these barriers wouldn't stop a younger individual from playing as they were perceived as preliminary issues of acclimatisation to the exergame and they would get used to it. Older adults that had trialled the Mira™ exergame felt the pace of Mira™, the instruction and the screen was similar to that of the Wii™ yet was more challenging and balance specific. Both young and old participants agreed that more work is required in order for older adults to be able to use exergames for balance training, which coincides with a feasibility trial here (Williams et al., 2010). It is for this reason that Mira™ became a better option, more so than commercially available exergames on the Wii™ and the Kinect™, for use in the pilot intervention. The older adults in the study suggested that Mira™ would be more optimal for individuals that struggle more so with balance, which coincides with the more fragile cohort intended to be recruited for the pilot intervention (fallers).

An important point to note is that for older adults to accept and use exergames, there must be a social factor, or connection, as social connectivity is an invaluable basic benefit of age-friendly community environments (Menec et al., 2011), which can help to build social networks and to avoid social isolation, especially in the older population (Courtin and Knapp, 2017). This finding contributes the existing evidence from chapters 2 and 3 in that none of the included studies performed exergames in the home environment alone. This finding also emphasises the importance of encompassing the user at the centre of the design of exergames (Skjaeret et al., 2015), to facilitate social enjoyment, which has been recently demonstrated over a period of three years in older adults (Brox et al., 2017).

4.2.4.2 Limitations of the study

Age-related differences were a focus of this study, yet this study failed to recruit adults over 65 years old. Differences exist between individuals over the spectrum of older age due to a more rapid decline in functional and cognitive capabilities and further research with this population is critical (Gerling et al., 2010). Participants in this study were recruited via Northumbria University or were part of an existing database at the University. Therefore, the scope of the perception of exergaming in terms of its usability and acceptance may not be transferable to contexts, situations and populations outside the scope of this thesis. All individuals involved in this study were healthy adults, although medical information was not obtained. The perceptions of acceptance and usability of exergames may indeed differ to individuals that may have had incidences compromising their balance when using exergames. In order to provide transparency in the design of this study, RT has provided key information on the number of organisations taking part in the study and where they are based, the number of participants involved in the fieldwork, the data collection methods that were employed and the number and length of the data collection sessions. Additionally, it could be argued that there was the lack of a reflective appraisal of the process of enquiry undertaken throughout this study, which would make it difficult for a researcher to comprehend how decisions were made and if they were successful and to what criteria. A final limitation was that participants did not trial the exergames for a long period of time, therefore were only able to reflect on perceptions of short-term use. Further research would benefit from exploring long-term perceptions of exergames in order to identify if perceptions change with more use.

4.3 Chapter summary

Commercial exergames are enjoyed by adults up to 63 years, however, console and exergame barriers become more apparent with age, which impact intention to use exergames to train balance. It appears that, with age, adults do not lose their competitive streak and prefer to use exergames more so with others than alone. The nature of commercial exergames were fun and enjoyable, yet, the older cohort of the study preferred the instruction and game pace of the Wii™ exergame, that which a younger cohort felt was outdated. The introduction of a tailored exergame (Mira™) to the older cohort was also enjoyed and participants felt that although using the Kinect™ console, the instruction was similar to the Wii™, which was preferred. The older cohort also felt that the exercises on Mira™ were more targeted towards balance and would be appropriate for individuals suffering balance impairments. These findings have been considered and have justified the selection of Mira™ to be used in the pilot intervention. Future research is needed to investigate the perceptions of a tailored exergame with across the spectrum of older age, as physical and cognitive capabilities decline more rapidly. The lack of perceptions from an older cohort and the targeted balance training indicated that the safest option was to use Mira™ over commercially available exergames for the pilot intervention.

5.0 STUDY 2 - PILOT INTERVENTION

5.1 Introduction

To briefly summarise the development work of the first phase of the Medical Research Council (MRC) framework for developing complex interventions, this thesis conducted two systematic reviews and the available evidence suggests that exergaming interventions are equally as beneficial as traditional balance interventions. The evidence suggests that exergaming interventions do not measure all of the components of postural control, in conjunction with the Systems Framework for Postural Control (SFPC). Nor do they fully train all of the movements that are linked to the various components of postural control, according to the SFPC, using commercially available exergames. Although further research is warranted to determine the link between the areas of postural control trained or not trained and the effect size of the intervention via mathematical modelling. The quality of the evidence at the study level was mediocre, but at the outcome level was low and the risk of bias was high and there was a substantial level of methodological heterogeneity in study designs. This supports the use of a novel outcome measure not yet used in exergaming interventions to the authors knowledge, which measures 8 out of 9 components of postural control in accordance with the SFPC. While not measuring all components, the chosen scale to assess postural control in the pilot intervention measures more components of the SFPC than any of the scale in the review of the literature. The evidence from the focus group study suggests that exergames do appear to be enjoyable for all ages, yet, the emergence of exergames from the gaming sector tailors their use to a younger cohort. Perceptions of exergames to train balance differ among the young and the old, with an older cohort displaying greater behavioural intention (technology acceptance), whom do not lose their competitive nature with age and prefer to use exergames to train balance with others. This paved the way for the choice to use Mira™ over commercial exergames on the Wii™ and the Kinect™ as games designers considered an older population at the heart of its design, participants perceived the exercises of Mira™ to be more balance targeted than commercial exergames, the instruction was clearer, the screen less complex and game play easier to follow. This chapter will describe and assess a pilot intervention on the feasibility of implementing Mira™ in the local community compared to a fall prevention class with similar movements and a no exercise control group among older adult fallers. The pilot intervention will employ the outcomes from the development work in phase 1 of this thesis. The pilot intervention took place in the north east of England, UK.

5.2 Implementation of a pilot intervention to assess the feasibility of using a tailored exergame to improve postural control in community-dwelling older adults.

5.2.1 Introduction

5.2.1.1 Background

Exercise-based behaviour change interventions can prevent or slow down the incidence of falls in older adults (Tricco et al., 2017). Fall prevention guidelines highlight the importance of exercise with strength and balance components in order to counter the declining physiological systems responsible for maintaining postural control (National Institute for Health and Care Excellence, 2013a) . Specifically, NICE public health guideline PH44 explicitly states that “Older adults (65 years and over) who are at risk of falls should incorporate physical activity to improve balance and coordination on at least 2 days a week” (National Institute for Health and Care Excellence, 2013b). Exergaming (exercise-gaming) was introduced as an alternative mode of balance training delivery to combat the lack of adherence and motivation towards traditional balance training for older adults, prone to falls (Laufer et al., 2014). The use of exergames for balance training indicate that outcomes improve similarly to current standard practice through use of commercial exergames such as the Nintendo Wii™ and the Xbox Kinect™ (Barry et al., 2016, Merriman et al., 2015, Whyatt et al., 2015, Pluchino et al., 2012, Sato et al., 2015). However, barriers exist in the use and acceptance of commercially available technology by older adults (Nawaz et al., 2016, Vaziri et al., 2016). Commercial exergames, created primarily for use with younger adults, often fail to consider older adults needs in various processes surrounding the interaction with exergaming systems and games. The setting up and navigating of the console, the complexity of the screen (object colour, size and speed), the level of instruction and inconsideration of their movement capabilities have previously been highlighted through various methods of qualitative assessment (Nawaz et al., 2014, Wuest et al., 2014, Skjaeret et al., 2015, Harrington et al., 2015). Exergames such as Wii Fit™ have shown to mainly train static and dynamic postural control within the base of support (BoS) and fail to encourage multidirectional stepping movements and control of balance dynamically (van Diest et al., 2013, Tahmosybayat et al., 2018), fundamental mechanisms in fall prevention. The motion capture technology of the Kinect™ is more favourable, is deemed less of a safety hazard for use with older adults and has enabled more freedom of movement during exergames (see chapter 4). Tailoring exergaming interventions to the population of interest is necessary to see sustained adherence and use of this method to train balance. Mira™ (Mira Rehab Limited) (Cantea et al., 2017) is an exergame designed for use with older adults and younger adults with debilitating conditions. Mira™ considers the older adults capabilities and sensitivities in that the game operates in a similar manner to going to see a physiotherapist. Initial screening and diagnosis can be documented, movements based on scientifically underpinned training programmes can be selected, selection of exergames to choose from and screen complexity is kept to a minimum. A key feature of Mira™ is the ability to calibrate the movements that drive the exergame to the movement capability of the user. A second key feature is the ability to save the schedule of games to repeat within the same session or at a next session. Something not possible in several commercial exergames.

5.2.1.2 Tailoring exergames and rationale for the pilot intervention

Exergaming interventions remain promising yet problematic due to variation in intervention delivery regarding technology, mode of delivery and intensity (Tahmosybayat et al., 2017). Tailoring the intervention for older adults requires considering the user at the centre of its design (Skjaeret et al., 2015). Using current recommendations to implement complex community-based interventions (Craig et al., 2008), there is a need to investigate if an exergaming intervention “can be done” in the local community in the north east of England for older adult fallers. The pilot intervention is described and adheres to the Template for Intervention Description and Replication (TiDieR) checklist (Hoffmann et al., 2014) (Appendix I) and follows the format outlined in the Consolidated Standards of Reporting Trials (CONSORT) extension statement for pilot and feasibility trials (Eldridge et al., 2016a) (Appendix J).

5.2.1.3 Aims and objectives

To investigate the feasibility of delivering a low-cost exergaming intervention (Mira™) aiming to improve postural control in the community for older adult fallers. This study reports on recruitment rates, adherence and completion rates of training and assessments, and the use of the Mini-Balance Evaluation Systems Test (Mini-BESTest) as the potential primary outcome measure to assess postural control in a future RCT. In addition to administering the Mini-BESTest, this study aimed to instrument task 14 of the test, the timed up and go (TUG) and the TUG dual task (TUGDT) using a body-worn monitor (BWM) to support the observation of the assessor by comparing the time in seconds of a stop watch versus the beginning and end of the task according to the BWM (see chapter 2). This study also reports on potential secondary outcome measures investigating the effects of an exergaming intervention on self-reported balance confidence, fear of falling, fatigue, well-being, cognitive impairment, depression, technology acceptance, flow and physical activity enjoyment. This study also implements assessing physical activity at baseline and post assessment during exergaming interventions through the use of the BWM over a 7-day period. Previous research has used BWM's such as the activPAL professional physical activity monitor (PAL Technologies Ltd, Glasgow, Scotland) to more accurately measure physical activity to gain a better understanding of the relationship between physical activity and disease prevention (Ryan et al., 2006)

5.2.2 Methods

5.2.2.1 Pilot intervention design

This was a non-randomised pilot intervention based on the design and development stages recommended by the Medical Research Council (MRC) in leading up to a randomised trial. The three groups of the pilot intervention were an exergaming balance training (Mira) group, a standard practice fall prevention (Steady) group and a no-exercise (Control) group.

5.2.2.2 Ethics

This study received clearance from the ethics committee at the University of Northumbria (HLS706- Appendix K). All study participants provided informed consent (Appendix L).

5.2.2.3 Participants

Community-dwelling older adults that had fallen twice in the last 12 months, living in the North East of England, UK, were recruited between June 2017 and January 2018. To determine feasibility and suitability of eligibility criteria, RT discussed the criteria with experienced physiotherapists (KB), biomechanists (GB, NC) and an engineer (AG) (Table 5.0). A qualified Postural Stability Instructor (PSI) was responsible for delivering the Staying Steady programme (balance training classes) (Hedley et al., 2010).

Table 5.0 - Eligibility criteria for participants in the pilot intervention

Inclusion criteria	Exclusion criteria
1) Older adults over the age of sixty years 2) Had fallen once or twice in the last twelve months 3) Were without neurological, musculoskeletal or medical conditions that affected their ability to perform daily activities 4) Could ambulate freely with or without an assistive device if necessary 5) Had not been involved in another balance based training programme three months prior to the intervention.	1) Adults under the age of sixty years 2) Had fallen more than twice in the last twelve months 3) Individuals with neurological, musculoskeletal or medical conditions that affected ability to perform daily activities 4) Individuals in assisted living facilities or nursing home residents 5) Individuals that had taken part in another balance training programme within three months of intervention start date.

5.2.2.4 Recruitment and eligibility

Two sites were responsible for recruitment. Northumbria University and Gateshead Older Peoples Association (GOPA). Recruitment was staggered in that start times and recruitment periods for each group differed. The Mira group participants were offered remuneration for travel and time to come to Northumbria University (£100). Participants in the Steady and Control group did not receive remuneration for their time involved in this study, which is understood could have implications on the acceptance of the intervention and indeed any differences in the perceptions of alternative modes of balance training. Participants in the Mira group were contacted via email from an existing database at the Brain, Performance and Nutrition Centre, Northumbria University. Participants were selected based on the age demographic (≥60 years). Older adults aged 60-64 years are not categorically high risk older adults, yet the implementation of fall prevention strategies tends to focus on individuals aged 65 years and above. Previous work found that behavioural interventions in adults aged 55 to 70 years led to long term improvements in physical activity at 12 months which have substantial health benefits in reducing the risk of age-related illnesses (Hobbs et al., 2013). To intervene at the age of 60 years provides the opportunity to minimise the reduction in physical activity levels which ultimately will have an effect on balance and mobility, which in turn can help to reduce the risk of falls. Therefore, participants responding with interest received an additional email with participation requirements and information concerning the correct definition of a fall. Participants meeting the inclusion criteria attended the university to give consent and begin the first assessment.

Participants in the Steady group were recruited via the GOPA Staying Steady programme recruitment process: self-referral, friend-referral, a General Practitioner (GP), the Falls and Syncope Service (FASS) or from viewing an advertisement. Participants were contacted by phone to carry out initial screening against inclusion criteria for the Staying Steady programme. Those interested were invited to the Staying Steady programme by post, which included the registration forms and initial screening assessment surveys. An additional phone call was made by the PSI to screen participants for inclusion in the pilot intervention for those already signed up to Staying Steady. If participants were interested, the PSI briefed two members of the research team (RT and GB) on the numbers and contact details. Once participants were screened, they were given an appointment at their local village hall to give consent and undergo the first assessment visit.

Participants in the Control group were recruited via both sites (GOPA and Northumbria University). This involved RT approaching individuals via an ongoing “meet up” café in the same locations as Staying Steady in Gateshead or individuals were invited to come to the university via email or word of mouth. An initial explanation of the study and the correct definition of a fall was given to participants by RT followed by an invitation to participate. If individuals were interested, they were given a participant information sheet, were screened against the inclusion criteria and given an appointment at their local village hall or at the university to give consent and for the first assessment visit.

5.2.2.5 Intervention descriptions

5.2.2.5.1 Mira individual exergaming sessions

Participants attended the laboratory twice per week for a 45-minute session, whereby 30 minutes were spent balance training using the Mira™ system. There was one day of rest between each training visit. This amounted to 2 assessment visits and 12 training visits. Upon arrival to the laboratory, each participant was logged onto the Mira™ platform and immediately began their training session. The set-up of the exergame environment can be found in figure 5.0.

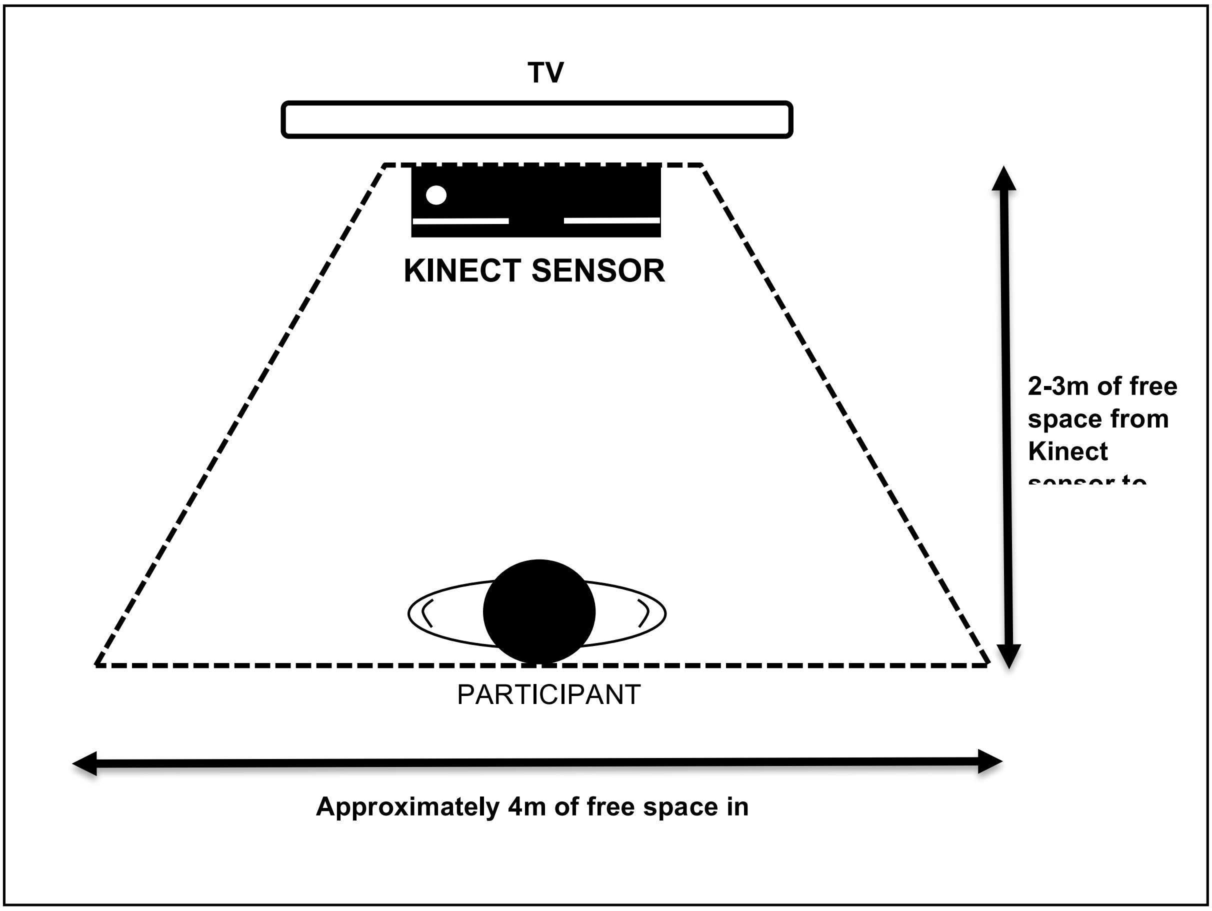

Figure 5.0 - Floor diagram of Mira™ exergame environment set up

Participants were explained the setup of the console including their profile on the games platform, the types of movements required during the session and the dynamics of calibration, movement tutorials, game tutorials and instructional feedback from Mira™. Several exergames were demonstrated with opportunities for any participant questions. There were 22 exergames in each session, lasting 1 or 2 minutes depending the intensity of the exercise, all with 15 seconds rest between each.

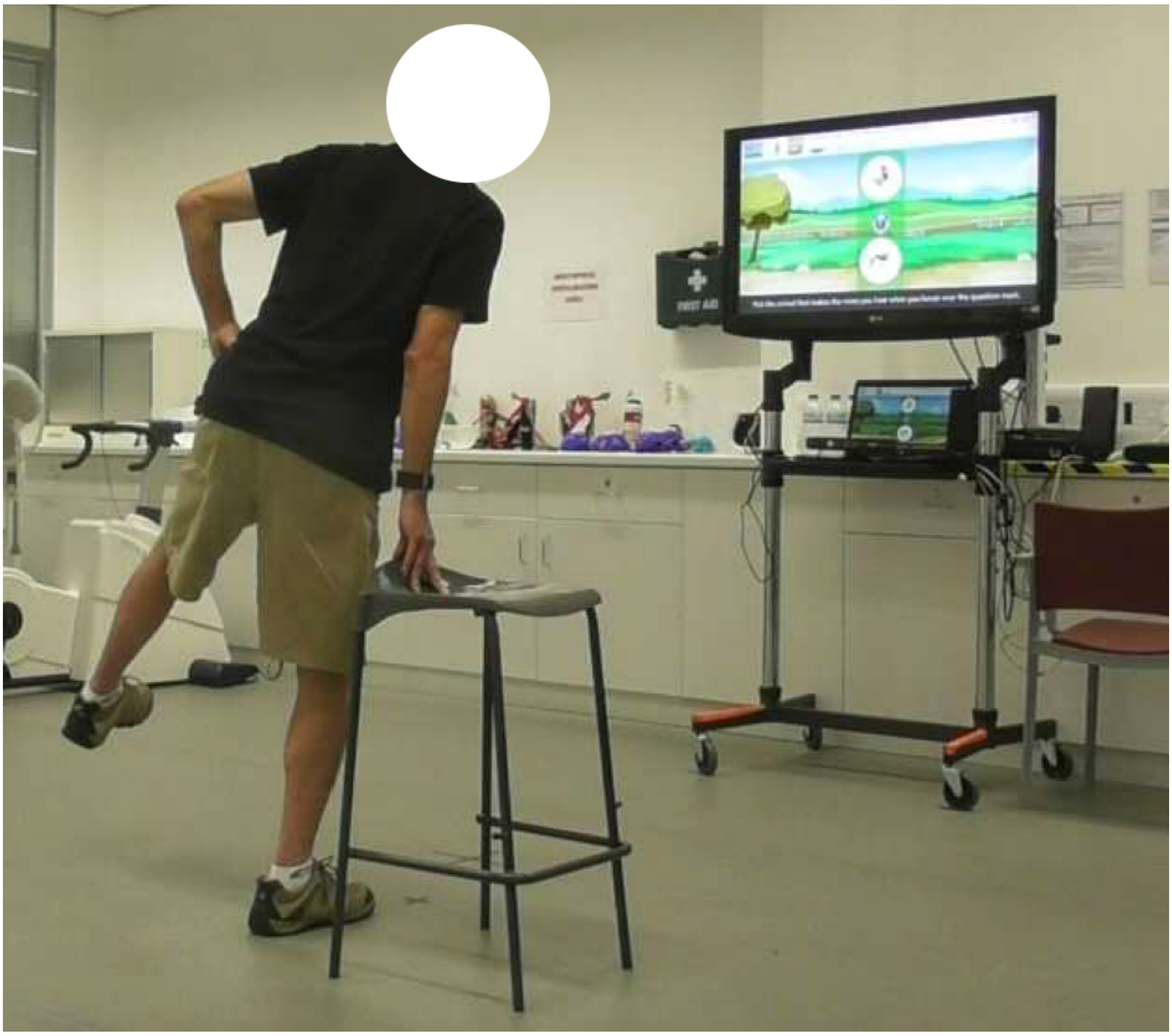

Figure 5.1 - An example of a participant playing a game on Mira™

The design of the schedule was based on the movements in the Mira™ platform that focused on balance, flexibility, coordination and strength. The movements chosen facilitated gradual participation into the schedule with the most intense exercise of each session occurring in the middle of the schedule. Upon completion, the participant specific schedule was saved on the Mira™ platform and an overall game statistic (sum of the number of points earned in each game) was presented to the participant. This statistic was used as an intrinsic motivational tool to enhance individual adherence during training and adherence to the programme over the 6 weeks. This was a finding from the preliminary work (chapter 4) conducted prior to the implementation of the intervention in that participants reported on receiving instant feedback and motivation to increase the score on a session by session basis. Mira™ automatically captured and displayed an image of each participant during each exergame for monitoring purposes, ensuring correct data captured. Refreshments were provided for all participants and support was made available, in the form of one or two chairs, for participants to hold onto during exercise throughout all training sessions. Changes to the participants schedule and use of chairs were recorded. For example, all levels of the games began on the easiest/lowest setting and progression was monitored by observing participants performance and from the overall score. On a weekly basis, the exergames were altered but the movements remained the same and in the same order. This varied the speed and number of repetitions each week with the added difficulty of unfamiliar intensity and cognitive load with the changing game element. If there were any movements that were too strenuous for a participant, an alternative movement of similar intensity was offered (Appendix M).

5.2.2.5.2 Steady (Staying Steady group class)

The Steady group were previously allocated to a 20-week programme whereby individuals would visit their local community hall once per week for 60 minutes of training immediately followed by a 30-minute informal educational discussion. The programme ran during the hours where local residents over 60 years old had access to free bus travel and participants in the programme were offered a card for easier access onto and off the bus as an incentive to use the transport services. Additional information is available in (Hedley et al., 2010). This consisted of eight visits (two assessment visits and six training visits), each visit lasting up to 1 hour 30 minutes. A course overview of the Staying Steady programme can be viewed in Appendix N.

Succinctly, each individual session would comprise of a warm up (10-15 minutes) followed by cardiovascular exercise (10 minutes), balance training (10 minutes), strength training (10 minutes) and floor work (5 minutes). The training would progress slowly over the 20-week period to the point whereby individuals are expected to perform class circuits from weeks 15 to 20. The Steady group additionally received educational elements each week (Appendix O). The assessment visits were conducted by RT and the training sessions were led by the PSI employed by GOPA. Due to the length of the balance training programme lasting 20 weeks, it was not possible to perform follow up assessments and therefore participants only had baseline and post assessments.

5.2.2.5.2 Control Group

After baseline assessments, the Control group were informed to go about their daily activities as usual and were given an appointment for the post assessment six weeks later. They were informed not to attend other balance training programmes or begin new exercise regimes until after the post assessment visit.

5.2.2.6 Potential outcome measures for a future trial

5.2.2.6.1 Postural control assessment

All outcomes were collected at baseline (T1) and post intervention (T2). The primary clinical outcome measure for potential use in a future trial was postural control, objectively assessed using the Mini-BESTest. The latter was developed, via Rasch analysis, (Franchignoni et al., 2010) to combat the limitation of the Balance Evaluation Systems Test (BESTest) time to administer (Potter and Brandfass, 2015). It is a 14-item scale across four subscales: anticipatory postural control, reactive postural control, sensory orientation and stability in gait. Each item is scored on a 3 point ordinal scale (0 = severe, 1 = moderate and 2 = normal) with a maximum score of 28 points (King and Horak, 2013). The Mini-BESTest has excellent to good reliability when used for individuals with stroke (Tsang et al., 2013), Parkinson's Disease (Leddy et al., 2011) and mixed diagnoses (Godi et al., 2013) (ICC >0.90). The Mini-BESTest has high content validity (Franchignoni et al., 2010), and has demonstrated criterion-related validity in several studies (Bergström et al., 2012, Godi et al., 2013, King and Horak, 2013, Leddy et al., 2011, Tsang et al., 2013). Minimal clinically important difference (MCID) differences are patient derived scores that reflect changes in a clinical intervention that are meaningful for the patient (Jaeschke et al., 1989). Their argument was that although statistically significant changes often occurred through use of instruments that measured change after intervention, in some cases the significant change had little clinical significance. The Mini-BESTest MCID score for a mixed population of individuals with imbalance is 4 points (Godi et al., 2013) and for post stroke individuals is 3 points (Tsang et al., 2013). This form of postural control evaluation has not been used in exergaming interventions despite its development from the Systems Framework for Postural control (SFPC) (Horak, 2006) and its ability to identify the physiological system responsible for postural control deficits (Refer to chapter 2). For a future definitive RCT, it is important to understand the feasibility of administering the Mini-BESTest in terms of tester or participant burden, the number of assessments, the time to assess and space to conduct assessments and how preliminary results compare to the change observed in a mixed population with imbalances (Godi et al., 2013), particularly pertaining to the MCID score.

5.2.2.6.2 Instrumented postural control assessment

We wanted to understand if it would be possible to simultaneously instrument task 14 of the Mini-BESTest, the timed up and go (TUG) and the TUG dual task (TUGDT), with a low-cost tri-axle accelerometer-based body worn monitor (BWM) worn on the fifth lumbar vertebrate (L5) (Axivity AX3, York, UK, dimensions: 2.3cm×3.3cm×0.8cm, weight 9g: sampling frequency 100-Hz, resolution: 16-bit, range: ±8g). This involved triple tapping the BWM before and after the 14th task of the Mini-BESTest. The aim was to objectively support the judgement of the assessor and combat the limitations of floor effects and lack of ceiling effects seen in populations with various conditions and levels of severity (Chinsongkram et al., 2014; Franchignoni et al., 2010; Godi et al., 2013; Tsang et al., 2013). Two minutes prior to the start of the assessment, the BWM was programmed and immediately attached. Following the assessment, participants were briefed on maintenance and adherence to wearing the device and were given an instructional sheet for reattachment of the device, to log reattachment activity (time, date and location) and note any adverse events during the 7 day periods at T1 and T2 (time, date, brief description) (Appendix P). Data were collected and are presented in the time domain (seconds) and compared to that of a stop watch (seconds), operated by the assessor (RT). No exergaming interventions currently have used such a method to support the judgement of the assessor in administering functional assessments of postural control objectively and this is the first, to our knowledge that has implemented the process (see chapter 2).

5.2.2.6.3 Instrumented physical activity assessment

BWMs have previously been used to assess the sedentary behaviour of office workers in conjunction with recommended guidelines (Ryan et al., 2011). The use of BWMs have previously been used to quantify ambulatory activity in older adults and older adult clinical populations (Godfrey et al., 2008, Godfrey et al., 2013, Godfrey et al., 2014, Godfrey et al., 2015, Del Din et al., 2016a, Del Din et al., 2016c, Hickey et al., 2016, Del Din et al., 2016b, Del Din et al., 2017). Previous research has explored the use of BWMs for analysing sedentary behaviour using the power law exponent *α* and the GINI index *G* (Chastin and Granat, 2010). They compared bouts of sedentary behaviour among healthy individuals with an active occupation, healthy individuals with a sedentary occupation, individuals with low back pain and individuals with Chronic Fatigue Syndrome. Although total sedentary time was not significantly different across the groups, the accumulation (duration and frequency of bouts) of sedentary time differed significantly ($p < 0.01$). Sedentary groups took fewer but longer bouts of sedentary time and active groups broke the sedentary time into more frequent shorter bouts of sedentary time. Other work has objectively quantified sedentary behaviour and ambulatory activity outcomes in retired and non-retired older, community-dwelling adults using an activPAL™ physical activity monitor (accelerometer) for seven consecutive days (Godfrey et al., 2013). Results indicated that being retired was associated with a reduced percentage of sedentary behaviour; reduced long bouts of sitting (>55 min) and increased the percentage of ambulatory activity (Godfrey et al., 2013). Results also indicated that volume of sedentary behaviour increased with age and the volume of ambulatory activity reduced. When compared to recommended physical activity guidelines for older adults, only 21% achieved the recommended 150 min per week (accumulated in ≥10 min bouts of walking). The opportunity to implement and monitor physical activity objectively, using a BWM, during a behaviour change intervention, provides the opportunity to direct behaviour change in a more concise, tailored and goal-oriented manner (with respect to public health guidelines). We implemented a similar approach in our study to monitor instrumented physical activity in the pilot intervention. We assessed physical activity to understand if the intervention altered PA levels. We assessed the feasibility of instrumented physical activity outcomes over the 7-day periods at T1 and T2 with the use of a single low-cost tri-axial accelerometer-based BWM (AX3, Axivity, York, UK, dimensions: 2.3cm×3.3cm×0.8cm, weight 9g: sampling frequency 100-Hz, resolution: 16-bit, range: ±8g) worn directly on the skin at the fifth lumbar vertebrate (L5). Here, the objective was to understand if any application, compliance, and safety issue with wearing such a device. We wanted to explore if this method of assessing PA would be suitable in a future trial to compare ambulatory and PA patterns against weekly recommended guidelines for older adults of 150 minutes of moderate aerobic activity (Nelson et al., 2007). Data was presented as the number of steps, number of bouts spent walking more than 2 minutes, the overall number of minutes spent walking in 10-minute bouts accumulated and compared to the 150 minute guidelines, the number of bouts spent walking more than 10 minutes and the overall number of minutes spent walking in 10-minute bouts accumulated and compared to the 150 minute guidelines. Two minutes prior to the start of the Mini-BESTest, the BWM was programmed and immediately attached. Following the Mini-BESTest, participants were briefed on maintenance and adherence to the maintaining application of the BWM and were given an instructional sheet for reattachment of the device. They were instructed to remove the device only during bathing or water-based activities (i.e. swimming), to log reattachment details (time, date and location) and note any adverse events during the 7 day periods (time, date, brief description). Devices were returned at a predefined time between the participants and research team.

5.2.2.6.4 Subjective self-report assessment

Exercise and physical-activity interventions have been known to have beneficial effects across several physical and mental-health outcomes (Penedo and Dahn, 2005, Penninx et al., 2002, Arent et al., 2000). As part of the preliminary analysis of this thesis, an outcome from the first systematic review (chapter 2) revealed that several interventions had implemented primary outcome measures such as a rating scale, secondary outcome measures such as self-report questionnaires and a tertiary outcome measure such as force plate postural control assessment. Interventions implementing self-report assessment, aimed to gain insight into perceptions surrounding balance confidence and fear of falling (Pluchino et al., 2012, Lai et al., 2013, Merriman et al., 2015, Whyatt et al., 2015). The Falls Efficacy Scale – International (FES-I) has shown excellent internal and test–retest reliability (Cronbach's α=0.96, ICC=0.96) to assess fear of falling during typical daily activities (ADLs) (Yardley et al., 2005), has been validated longitudinally and FES-I scores have shown to increase more rapidly with multiple falls within a three month period (Delbaere et al., 2010). The Activities – specific Balance confidence Scale (ABC Scale) (Powell and Myers, 1995) has previously been employed to determine whether balance confidence differed between fallers and non-fallers, and whether the scale predicted falls (Lajoie and Gallagher, 2004, Cleary and Skornyakov, 2017, Moiz et al., 2017). Cleary and Skornyakov, (2017) found significantly lower total ABC scores (less confidence) for fallers (50.6%) than non-fallers (76.3%) ($t = 3.49$, $p = 0.001$), whereby fallers reported lower balance confidence on all 16 individual ABC items. Further investigation revealed that the total ABC score predicted the number of falls at 6 months ($F = 9.86$, $p = 0.003$, $\beta = -0.44$, R2= 0.19), although, the model fit total ABC score only managed to classify 36.4% of fallers correctly. This could be due to classifying falls on frequency alone rather than considering the context of the pre-fall event (Ross et al., 2017). The Hindi version of the ABC scale was examined to discriminate between fallers and non-fallers and its predictive validity for prospective falls (Moiz et al., 2017). Findings also suggest significant differences (52.6 ± 8.1 vs 73.1±12.2; $p < .001$). The scores were also independently related with future falls in community-dwelling Indian older adults (dichotomized total ABC-H scale score of ≤ 58.13% (adjusted odds ratio =0.032, 95% confidence interval =0.004–0.25, P=0.001). The ABC scale has shown internal consistency (0.94) and test – retest reliability (ICC = 0.85 (95% CI, 0.68, 0.93)) in older adults, post one year stroke victims (Botner et al., 2005).

We also aimed to gain insight into self-report measures of fatigue using the Functional Assessment of Chronic Illness Therapy Fatigue Scale (FACIT) (Chandran et al., 2007). This scale has been considered reproducible (ICC = 0.95), and correlated well with other fatigue measures (−0.79 (95% CI −0.85 to −0.72). The FACIT fatigue scale has shown lower scores in patients with overwhelming fatigue and fibromyalgia than in those without (p<0.001), as well as with disease activity in individuals with Psoriatic Arthritis (PsA) (Chandran et al., 2007).

Exercise has previously been associated with improved mood in the elderly (Arent et al., 2000). We wanted to implement an outcome measure to understand any potential effects of the pilot intervention on depression for older adults. The Geriatric Depression Scale – short form (GDS-15) (Sheikh and Yesavage, 1986) has previously been validated for detection of major depressive episodes according to the International Classification of Diseases (ICD-10) symptom checklist for mental disorders criteria for research and the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV). GDS-15 has shown to be a good screening instrument (sensitivity and specificity rates of 92.7% and 65.2%, respectively) for major depression when using a cut-off point of 4/5.

Cognitive impairment is a predictive discriminator of fallers and non-fallers in that fallers tend to score lower than their non-falling counterparts (Lord and Clark, 1996).We implemented the Mini-Mental State Examination (MMSE) to assess cognitive impairment during the pilot intervention (Folstein et al., 1975, Folstein et al., 1983).

We also implemented the Standard Form 36 questionnaire (SF-36) (Jenkinson et al., 1993) to assess well-being during the pilot intervention. The questionnaire consists of 36 items divided in to 8 subscales (physical functioning, social functioning, role functioning (physical and emotional), mental health, vitality, pain, general health perceptions and health change), which measure three aspects of health (functional status, well-being and overall evaluation of health). The impact of fear of falling has previously been assessed on the health of older adults (mean age 77 years) over 12 months (Cumming et al., 2000). SF-36 scores (particularly scores on the Physical Function and Bodily Pain subscales) tended to decline more among persons with poor fall-related self-efficacy. Non-fallers claiming to be afraid of falling had an increased risk of admission to an aged care institution (Cumming et al., 2000).

Additional questionnaires were also administered to the intervention groups (Mira and Steady) were to assess immersion, physical activity enjoyment and technology acceptance. Flow is a state in which an individual can become totally immersed within an activity. It has previously been described as “a mental state of operation in which a person is fully immersed in what he or she is doing” and there are nine dimensions which bring about the intrinsic motivation needed for flow: balance between challenge and skill, clear goals, unambiguous feedback, concentration of task, sense of control, action-awareness merging, transformation of time, loss of self-consciousness and autotelic experience (Csikszentmihalyi, 1990). Challenge-skill balance is a key contributor to an individual's state of flow. There is a need of equal balance between the skill level and the challenge of a task. A task too challenging or a task too easy may demotivate an individual, whereas feeling engaged but not overwhelmed by the challenge is an optimal state of flow. Flow state was assessed using the 36 item Flow State Scale (FSS) (Jackson and Marsh, 1996). Flow has been known to facilitate continued behaviour in lifestyle interventions such as exergaming to train postural control as people need to feel a sense of enjoyment and motivation to continue with the goal of the intervention. The flow state scale previously showed significant differences between randomised intervention groups in on several dimensions, with higher values in the Kinect-based exergaming group (Barry et al., 2016). The Wii Fit has also previously shown superiority in two dimensions of flow for individuals with Multiple Sclerosis (Robinson et al., 2015). We implemented the FSS to assess administration and acceptance of the questionnaire, and any potential differences in states of flow between the two intervention groups in the pilot intervention.

Facilitating enjoyment during physical activity has been known to have significant positive outcomes through continued involvement by means of countering stress and facilitating positive psychological health (Wankel, 1993). Enjoyment older adults feel towards the domain of physical activity is relatively unexplored. We implemented the Physical Activity Enjoyment Scale (PACES) (Kendzierski and DeCarlo, 1991) in the pilot intervention for the two intervention groups. Previous research has shown high internal consistency and test-retest reliability during alternate modes of exercise (Kendzierski and DeCarlo, 1991).

A modified version of the Unified Theory of Acceptance and Use of Technology (UTAUT) questionnaire (Venkatesh et al., 2003) was implemented to assess technology acceptance through behaviour intention. The UTAUT was designed to develop a unified model acceptable for analysing technology acceptance and use in the information technology field. The argument that exergames promote an optimal training stimulus through functional and coordinated movements in a graded instant feedback manner supports the use of this questionnaire in behaviour change interventions. This model has previously been employed to inform behavioural intention in a RCT of exergaming versus mirror matched gym based activities (Barry et al., 2011, Barry et al., 2016). The exergaming intervention arm had higher levels of technology acceptance in subdomains of performance expectancy, social influence and behavioural intention.

The feasibility assessment of questionnaires was to explore the time to completion, if the number of questionnaires was feasible and the feedback on completion of questionnaires by participants. Altogether, we administered six questionnaires for all participants and an additional three questionnaires for the two intervention groups at post-assessment.

5.2.2.7 Settings and location for data collection

Data was collected in different locations for the three different groups. All assessments and training occurred in the locations designated for each intervention group. Participants in the Mira group attended a laboratory for the assessments and the training programme at Northumbria University. The floor space was adequate for the balance training (2m x 4m) and to administer the primary outcome measure, the Mini-BESTest (5m x 8m). Participants in the Steady group attended three community locations in the North East, UK for the training and assessment visits. The PSI that led the group based balance classes previously assessed the floor space at the halls (ranged from 5m x 10m to 10m x 10m), which were deemed adequate for the balance assessments to be carried out. Participants in the control group attended their local village hall or came to the university for baseline and post assessment visits only.

5.2.2.8 Recruitment and eligibility assessment

The overall recruitment period began at the start of the first month and finished at the end of the last month for both sites involved. Group specific recruitment periods were extracted to account for staggering of recruitment start up times. These were then averaged over the number of sites to give an average group recruitment period. Overall recruitment rate was calculated as the total number of participants recruited divided by maximum number of sites recruiting, then divided by total number of months. Average recruitment rate was calculated as the total number of participants recruited divided by the maximum number of sites, and then divided by the average number of months recruiting. Consent rate was the number of individuals who met inclusion criteria versus number that consented to participate in the study; reasons why eligible individuals were not interested were recorded. Retention rate was the number of participants that completed data collection at post assessment divided by the numbers at baseline for each assessment objective.

5.2.2.9 Adherence and fidelity assessment

Participant adherence was assessed as the total number of sessions attended by participants. Trainer recruitment and adherence was assessed by the total number of sessions attended by the PSI for the Steady intervention group and RT for both groups. Participant and assessor burden was assessed by collecting assessment administration times (minutes) of the assessments.

5.2.2.10 Adverse events

Adverse events (AEs) can be considered serious or non-serious events that occur during the duration of a study. Serious adverse events (SAEs) may result in hospitalisation, are life threatening or worst-case scenario result in death (Shaw et al., 2005). Adverse events are not considered serious; however, can result in injury and is a reason for study drop out. This can influence the decision of whether an intervention is safe enough for a given population (Ory et al., 2005). Adverse events were monitored, solicited and recorded by direct observation by RT and the PSI during the intervention visits. During the weeklong physical activity monitoring and assessment, participants were asked to note down any AEs that occurred on the back of an information leaflet that described how to mount and dismount the BWM. Adverse events may be either related or unrelated to the intervention. Participants were asked to note the day and time of the event and a description of the event.

5.2.2.11 Sample size assessment

As this was a feasibility study, power and sample size calculation was informed from the estimation of eligible people who were willing to participate, drop outs and those who complied with their allocated intervention. The standard deviation of the primary clinical outcome measure (Mini-BESTest) assisted in estimating the sample size and formulate estimations for a future trial. In this feasibility study we adopted the sample size based on a previous pilot trial comparing a Wii™ group (n=12), a Tai Chi group (n=14) and a standard balance exercise group (n=14) (Pluchino et al., 2012).

5.2.2.12 Blinding

A single researcher acted as the clinician administering all assessments, data collection, outcome adjudicator and data analyst. Blinding the recommended individuals was not possible (Karanicolas et al., 2010). However, GOPA, the PSI and participants in the Steady group were blinded to the participants in the Mira group and the Control group.

5.2.2.13 Data analysis

Assessment outcomes pertaining to recruitment and eligibility, adherence and fidelity are presented descriptively and narratively whereby data are presented as percentages, raw counts or as time (minutes). Four measures of success (progression) criteria defined progressing to a full RCT. These criteria were derived from a feasibility study that implemented an adapted version of the Falls Management Exercise (FaME) programme (Skelton et al., 2005) for older adults with visual impairment (Adams et al., 2018) with the aim of conducting a future definitive trial. The four progression criteria were defined as:

1. > 50% of eligible participants recruited
2. > 70% of participants completing all training sessions
3. > 70% of participants completing all assessment visits
4. < 10% of participants sustaining an adverse event during the intervention period.

Proposed outcome measures are presented in a continuous measurement format as group mean values and standard deviation. Mean differences and 95% confidence intervals are also presented to compare the two intervention groups, from baseline to follow up, to demonstrate any clinical worthwhile difference between Mira^{TM} and Staying Steady. No sub-group or adjusted analyses were conducted.

5.2.3 Results

5.2.3.1 Recruitment and eligibility

Recruitment for the pilot intervention took place over a 12-month period from January 2017 to January 2018 with an overall recruitment rate of approximately 3 participants every 2 months. Recruitment was staggered for each group: Mira occurred between May and August 2017; Steady between January and September 2017 and; Control between October 2017 and January 2018. The average recruitment period across groups was 5.67 months. Initially, 280 people were identified and contacted via email, phone call or face-to-face invite. 59% (165/280) failed to respond, 11% (31/280) declined to participate, leaving 30% (84/280) suitable for eligibility. Of the 84 individuals assessed, 85% (71/84) were invited. 51% (36/71) of invited individuals were excluded due to lack of interest (44%, 16/36) individuals declined to participate due to lack of interest and 56% (20/36) failing to meet the inclusion criteria. Consequently 35 (69%) of eligible participants were included in the study (Figure 5.2), which succeeds the first progression criterion by 19%.

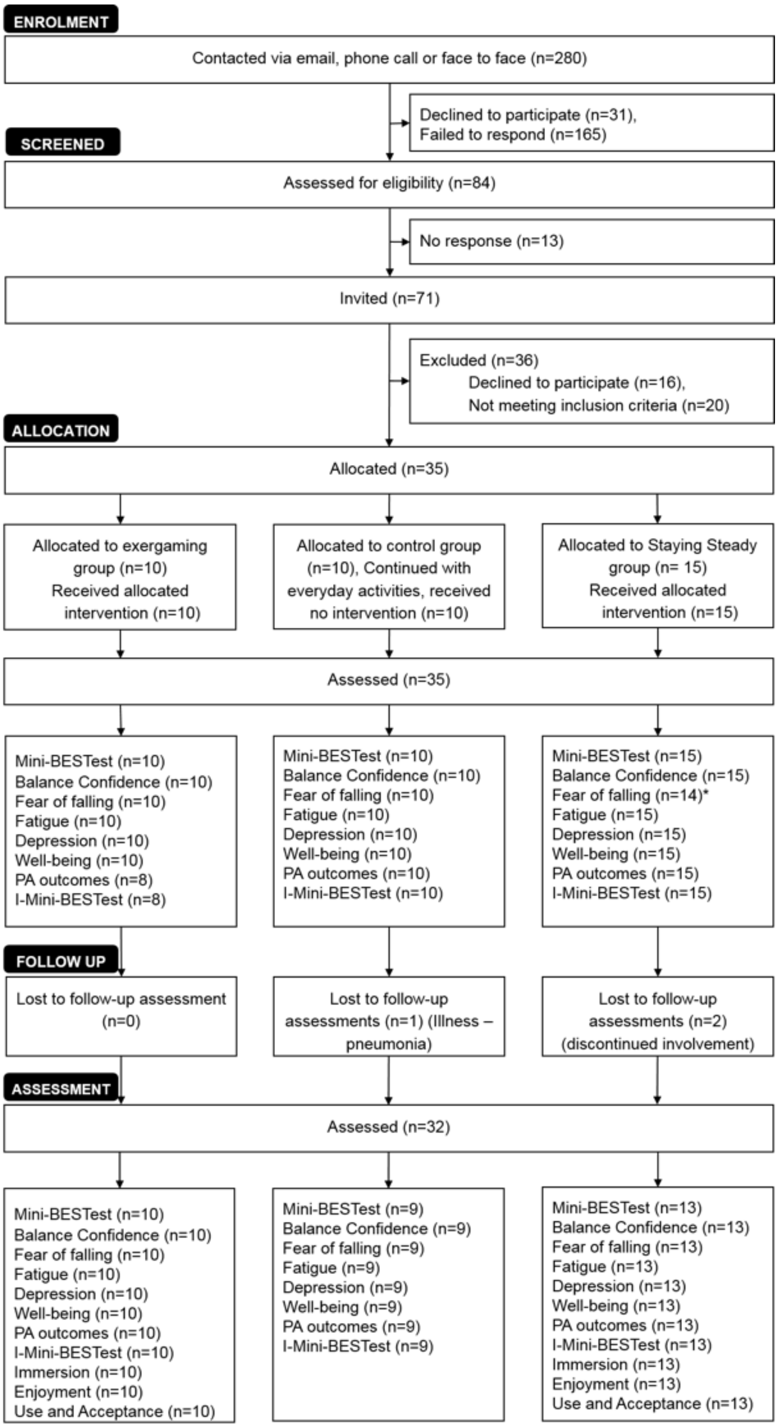

Figure 5.2 - Feasibility study flow diagram (CONSORT flow diagram)

5.2.3.2 Baseline demographic and clinical characteristics of participants

Baseline characteristics relevant to clinical outcomes are presented below in Table 5.1 for the three groups. Participants in the Steady group self-reported higher levels of fatigue, fear of falling and depression and lower levels of balance confidence at baseline compared to the Mira and Control groups. The Steady group scored lower for postural control evaluation from the Mini-BESTest and were less physically active.

Table 5.1 - Baseline demographic and clinical characteristics of participants divided by group

	Mira group (n=10)	Steady group (n=15)	Control Group (n=10)
Females to males (ratio)	7:3	13:2	7:3
Age (yrs)	67.6 (63, 85)	76. 7 (68, 83)	71.7 (61, 82)
Height (m)	1.67(0.11)	1.61(0.09)	1.66(0.08)
Mass (kg)	76.0 (16.46)	69.41 (12.91)	72.45 (13.69)
MMSE NCI (24-30 pts)**	10	15	10
FACIT Severe fatigue (<30pts)**	0	5	1
FES-I Low concern (16-19pts)**	2	2	4
FES-I Med concern (20-27pts)**	7	2	6

FES-I High concern (28-64pts)**	1	10	0
ABC High functioning (>80%)**	7	4	7
ABC Med functioning (50-80%)**	3	8	3
ABC Low functioning (<50%)**	0	3	0
ABC risk of falling (<67%)**	0	8	2
GDS suggestive of depression (>5 pts) **	2	1	1
GDS indicative of depression (≥ 10 pts)**	1	2	1
Mini-BESTest (/28 points)	19.90 (4.38)	14.31 (5.27)	22.89 (2.67)
Walking bout counts (≥ 10 min)	4.88 (3.4)	1.54 (2.7)	2.22 (2.0)
Walking activity ≥10 min (min)	82 (27.9, 224.4)	25.86 (0, 142.4)	25.16 (0, 68.8)
Walked >150 min in bouts ≥10 min**	2 (20%)	0 (0%)	0 (0%)

**= presented in counts per group, *=significant difference yrs = years, kg = kilograms, pts = points, MMSE = Mini-mental State Examination, NCI = No Cognitive Impairment, FACIT = Functional Assessment of

Chronic Illness Therapy, ABC = Activities Specific Balance Confidence Scale, GDS = Geriatric Depression Scale, Mini-BESTest = Mini-Balance Evaluation Systems Test.

5.2.3.3 Adherence assessment

Adherence to the training programme was considered 100% successful for both the Mira and Steady groups which succeeds the second progression criteria by 30%, although this value does not account for consecutive visits (Mira, 98% and Steady, 27%). This may be attributed to the nature of the referral to a group class for the Steady programme as opposed to the voluntary individual visits in the Mira group. Retention rate was 91% in that two participants in the Steady group declined to attend the post assessment session due to lack of interest to carry on participating. One participant in the Control group failed to attend post assessment due to illness (pneumonia). Assessment visits were only completed 100% by the Mira group, although the assessor (RT) failed to assess the instrumented Mini-BESTest and physical activity monitoring over a 7-day period for 2 participants due to problems with programming the BWM. The fault was the assessor failing to programme the BWM prior to beginning the assessments and not due to participants dismounting the devices or opting out of this particular assessment. Overall, the percentage of participants completing all assessments visits was 95.7%, which was 25.7% over the third progression criterion. Time was not recorded for each training or assessment visit; however, training visits would last approximately 45 minutes for the Mira group and the assessment visits 90 minutes. For the Steady group the training visits lasted approximately 90 minutes (60 minutes active, 30 minutes educational). The assessment visits for the Steady and

Control groups would last up 60 minutes as questionnaires were completed at home. Training and assessment visit counts and percentages are presented in Table 5.2.

Table 5.2 - Total number of training sessions attended by participants

Attendance n (%)	Mira group (n = 10)	Steady group (n = 15)	Control group (n = 10)
Training visits completed	120 (100%)	90 (100%)	N/A
Visits completed consecutively	117 (97.5%)	24 (26.7%)	N/A
Visits Rearranged	3 (2.5%)	0	N/A
Visits Scattered	0	66 (73.3%)	0
Assessment visits completed	20 (100%)	28 (93.3%)	19 (95%)
Assessment visits rearranged	0	2 (6.7%)	0
Assessment visit drop out	0	2 (6.7%)	1 (5%)

Twelve (100%) training sessions were attended by RT for the Mira group and all six (100%) scattered training sessions for the Steady group were attended by the PSI and RT. It must be noted that one PSI left during data collection and was replaced with another equally qualified PSI.

5.2.3.4 Administration assessment

The overall mean administration time of the potential primary outcome measure (Mini-BESTest) was 23.11 (5.5) minutes, assessed by the BWM. Group mean (SD) administration times are presented in Table 5.3.

Table 5.3 - Mean (SD) Mini-BESTest administration time (minutes) at baseline and post assessment for each group

Group	Pre	Post
Mira	22.9 (4.2)	18.7 (2.2)
Steady	21.8 (5.4)	26.4 (6.6)
Control	26.5 (4.3)	22.6 (3.7)

Administration of all potential outcome assessments were completed successfully (100%) at baseline for the control group only. The FES-I questionnaire was only completed by 14 (93.3%) participants in the Steady group. Physical activity and instrumented Mini-BESTest data were only collected for 8 (80%) participants in the Mira group due to the tracker not being programmed correctly prior to attachment for 2 participants. At post-assessment (T2), all assessments and questionnaires were completed successfully (100%) by the Mira group. Only 86.7% and 90% of all assessments and questionnaires were completed in the Steady and Control group, respectively, due to participant drop out at post assessment. Administration time of questionnaires were not recorded due to the Steady and Control groups completing questionnaires at home and the Mira group completing questionnaires in the session with RT. For the Mira group, the administration and completion of the questionnaires lasted no longer than twenty-five minutes.

5.2.3.5 Outcomes and estimation

5.2.3.5.1 Postural control assessment

Overall, postural control outcomes measured by the Mini-BESTest were higher at the end of the intervention for the Mira group compared to the Steady group with a mean difference of 5.57 points (2.29 to 8.86 95% CI). However, the scores at baseline were also significantly different for both intervention groups and a change score of 2.9 points from baseline to follow up occurred for both interventions groups. This suggests both groups improved equally over the duration of the intervention period. Neither intervention group attained a MCID of 4 points, although the duration of the intervention was significantly shorter than the recommended number of hours for fall prevention interventions (50 hours). This may suggest that an intervention of longer duration may yield greater results for both intervention groups and the change score may represent more closely to that to older adults with imbalances (Godi et al., 2013). Although this suggestion warrants further investigation in a robust RCT with more equally matched participant characteristics at baseline. The time constraints of this PhD meant that there was no time to investigate the sub-components of the scale. Previous research on older adults with idiopathic Parkinson's Disease investigated sub-components found the postural responses (reactive PC) to have the largest proportional measurement error and sensory integration to have the highest agreement for inter-rater and test-retest reliability (Löfgren et al., 2014). For a future definitive trial the scale should be broken down to understand which components of the SFPC were trained and which weren't with a tailored exergame.

5.2.3.5.2 Instrumented postural control assessment

The Timed Up and Go (TUG) and the Timed Up and Go with Dual Task (TUGDT) task of the Mini-BESTest using a BWM and a stop watch was performed more rapidly for the Mira group following the intervention. For the TUG and the TUGDT, the Mira group was 2.67 seconds (1.16 to 4.18 95% CI) and 5.82 seconds (2.75 to 8.89 95% CI) faster than the Steady group when measured using a stop watch operated by RT. Results were similar when measured using the BWM in that the Mira group were 2.74 seconds (1.29 to 4.19 95% CI) and 5.40 seconds (2.56 to 8.54 95% CI) faster than the Steady group, respectively. Interestingly, the differences between the two methods of assessment are not substantial when comparing between the groups. Observing change scores for both intervention groups, there was an improvement in TUG and TUGDT for both intervention groups when measured using the stop watch and the BWM. The Mira group improved in TUG from baseline to follow up by -1.05 seconds (-0.79 to 2.89 95% CI) when measured with a stop watch and by 1.12 seconds (-0.63 to 2.87 95% CI) when measured using the BWM. The Steady group also improved their TUG outcome at follow up assessments, although the measurement methods showed different results of -0.78 seconds (-1.75 to 3.31 95% CI) when measured using a stop watch and -1.44 seconds (-1.05 to 3.93 95% CI) when measured using the BWM.

The TUGDT took less time to complete for the Mira group than the Steady group. However, change scores for the TUGDT were greater for the Steady group whom improved by -2.71 seconds (-2.24 to 7.66 95% CI) and -2.86 seconds (-1.96 to 7.68 95% CI) over the intervention period when measured using the stop watch and BWM, respectively. The Mira group were significantly faster and improved by -1.24 seconds (-1.11 to 3.77 95% CI) and -1.37 seconds (-1.10 to 3.84 95% CI) when measured using the stopwatch and BWM, respectively. Interestingly and which coincides with differences observed at baseline between the groups, the Mira group timing to complete the TUG more relates to that of older adults without a history of falls (8.4 seconds with a range of 6.4 to 12.6 seconds) whereas the Steady group relates more to individuals that have experienced 2 or more falls in the last 6 months (22.2 seconds with a range of 10.3 to 39.2 seconds) (Shumway-Cook and Woollacott, 2010). The same occurred for the TUGDT in that participants in the Mira group performed more aligned with older adults without a history of falls. Shumway-cook et al., (2010) reported older adults without a history of falls had a mean time of 9.7 seconds with a range of 6.2 to 14.6 seconds to complete the TUGDT. The Steady group performed more similarly to individuals that had a history of falls (27.7 seconds with a range of 11 to 49.6 seconds). There appears to be greater values in all TUG and TUGDT tasks when measured using the BWM, which opens up the measurement assessment to ambiguity. Whether this ambiguity is significant, warrants further investigation. There are detriments to both methods of assessment in that using a stop watch, which is a gold standard method of administration, operator variability may provide differences in results. The same could be said for when measured using the BWM in that the operator had to tap the device as closely toward the end of the task as possible. A robust protocol when using a BWM will limit the variability if followed correctly and has been considered for use in place of a stop watch. The use of a BWM must develop a robust protocol and cut off times when marking the beginning and end of the task. This must be considered for standardisation of the assessment in a future RCT. The use of BWMs to quantify postural transition phases of the TUG and the TUGDT have previously been explored with older adults (Salarian et al., 2010, Coulthard et al., 2015). This form of assessment has the potential to provide clinicians with accurate, stable and sensitive biomarkers for longitudinal testing of postural control during gait (Mancini and Horak, 2010).

5.2.3.5.3 Instrumented physical activity assessment

All instrumented physical activity outcomes were higher at baseline and follow up of the intervention for the Mira group compared to the Steady group. This again shows how the intervention groups may not have been equally matched. The Mira group had 36.98 (15.88 to 58.08 95% CI) more 2-minute bout counts and 2.96 (0.13 to 5.79 95% CI) more 10-minute bout counts of physical activity than that of the Steady group. This was also evident in ambulatory activity in bouts of 2 minutes and 10 minutes, whereby the Mira group were 179.31 (62.68 to 295.94 95% CI) and 42.79 (-9.75 to 95.33 95%CI) minutes more active than the Steady group at follow up, respectively. Considering the total number of minutes in bouts of 10 minutes or greater, only two participants the Mira group and one participant in the Steady group attained the 150 minute guidelines during the intervention. This is an interesting finding considering the Steady group are advised as part of the Staying Steady programme to complete home exercise to meet this guideline and received prompts at each session to do so. However, overall, there was a lack of participants meeting the recommended guidelines before and after the intervention when performing bouts of more than 10 minutes of physical activity.

5.2.3.5.4 Balance confidence

Balance confidence outcomes were higher for the Mira group at baseline and follow up to the intervention. Although this is not a clear indication of which intervention was optimal for improving balance confidence outcomes, the Mira group were 25.77 percent (6.28 to 45.26, 95% CI) more confident in their balance following the intervention than the Steady group. The mean change score for the Mira group of 3.3 percent (-4.81 to 11.41 95% CI) corresponds with the responsiveness of the ABC score in community dwelling older adults (3.58) (Huang and Wang, 2009), whereas the change score for the Steady group of -1.71 (-17.99 to 21.53 95% CI) correlates more to the responsiveness of the ABC scale for geriatric females in a fall prevention group (-1.1) (Talley et al., 2008). This may support evidence of the differences between the groups at baseline and the need to more accurately match the groups for a RCT.

5.2.3.5.5 Falls efficacy

At post assessment, the Mira group appear to be less fearful in completing activities of daily living inside and outside of the house when compared to the Steady group. This coincides with differences observed in balance confidence. The Mira group were -7.97 points (0.57 to 15.37 95% CI) less fearful than the Steady group. Change scores for the two intervention groups were not dissimilar in that the Mira and Steady groups both reduced their fear of falling, however, the reduction was minimal. The mean change score for the Mira group was -0.9 points (-2.54 to 4.34 95% CI) and for the Steady group was -0.7 points (-8.53 to 9.93 95% CI). Interestingly, the mean (SD) FES-I score for participants in the Steady group was 29.77 (10.76), which compares more so with individuals that have had a fall in the previous year and are cognitively impaired, 29.7 (9.9) (Delbaere et al., 2010). The mean (SD) for the Mira group was 21.80 (3.58), which compares more so with individuals that are not fearful of falling at all 24.9 (9.1) (Delbaere et al., 2010). Participants in the Mira group saw minimal change in FES-I scores after six weeks of exergaming, which compares well to a Wii Fit feasibility study whereby no change in FES-I scores was observed after 12 weeks of Wii Fit exergaming (Williams et al., 2010). Williams et al. (2010) also found similar results in that although balance confidence improved in the intervention group, the FES-I scores did not and it could be that there is still fear present although participants feel more confident and the latter does not diminish as the other scale improves.

5.2.3.5.6 Depression

The range of depression scores for the Steady group corresponded with normative data in the literature (0 to 10 = no depression) as did the participants in the Mira group. One participant in the Mira group had a considerably high GDS score (14/15) at baseline, which reduced at follow up assessment (11/15) and was considered to have depression (Yesavage et al., 1982). Differences between the intervention groups at follow up assessment was minimal with 0.05 points (-2.66 to 2.77 95% CI). Change scores over the intervention period showed that the Mira group had a reduction of -0.7 points (-3.00 to 4.40 95% CI) compared to the Steady group, where by depression scores increased 0.29 points (-2.02 to 2.60 95% CI). Although, the range of depression scores were lower in the Steady group, the reduction appeared to be greater for the Mira group over time.

5.2.3.5.7 Fatigue

At follow up assessment, the Mira group were 6.17 points (-1.44 to 13.78 95% CI) less fatigued than the participants in the Steady group. Although, this does not reflect the rate of improvement in the FACIT scores at post assessment. When comparing change scores for the intervention groups, the Mira group improved by 1 point (-3.58 to 5.58 95% CI), whereas the Steady group had improved by 1.9 points (-8.96 to 12.76 95% CI). This could be associated with the participants in the Steady group perceiving their improvements in fatigue due to the use of Therabands within the class. A second suggestion is that the participants in the Mira group were more active than the participants in the steady group and the rate of improvement may not occur as rapidly as for the Steady group for this reason. This warrant further investigation in a RCT. Interestingly, the FACIT scores for the Mira group at post assessment compare more so with individuals that are not impaired and the Steady group compare more so with individuals with impairments (Knaggs et al., 2011).

5.2.3.5.8 Health-related quality of life

At follow up assessment, the Mira group had an SF-36 score of 13.62 points (-2.57 to 29.81 95% CI) higher than participants in the Steady group, although participants in the two intervention groups differed at baseline in terms of SF-36 scores. SF-36 global scores increased for both intervention group over the intervention period with the Mira group increasing by 2.5 points (-9.02 to 14.02 95 CI) and the Steady group increasing by 1.05 points (-16.44 to 18.54 95% CI). MCID scores of 3 to 5 points for the SF-36 were recommended based on effect size (Samsa et al., 1999). The Mira group were closest to reaching this MCID score with 2.5 points change over time. The MCID score of 3 to 5 points however is recommended for the individual subscales of the SF-36. Analysis of the subscales of the SF-36 revealed that the Mira group increased or remained the same in all but 1 sub-category of the questionnaire, General Health perception change by 1 point (-7.35 to 9.35 95% CI). The same could not be said for individuals in the Steady group that decreased by 7 points (-16.81 to 30.81 95% CI) and 3 points (-30.75 to 36.75 95% CI) in Physical functioning and Role Functioning/ Physical, respectively. This is an interesting outcome considering the intervention was focused on improving physical functioning through balance training, yet the perceptions of the participants in the Steady group appear to have decreased in their physical functioning health related quality of life scores.

Table 5.4 presents the descriptive statistics (mean SD) and between group mean difference (95% CI) for the Mira group and the Steady group for all outcomes. Table

5.5 and 5.6 presents the descriptive statistics (mean SD) and mean change scores for the Mira and Steady intervention groups for all outcomes, respectively. Table 5.7 presents descriptive statistics (mean SD) and mean difference (95% CI) for sub-categories of the SF-36 questionnaire between the Mira and Steady intervention groups. Table 5.8 and 5.9 presents the descriptive statistics (mean SD) and the mean change scores for the Mira and Steady intervention groups for the sub-categories of the SF-36 questionnaire.

Table 5.4 - Descriptive statistics, mean difference and 95% confidence intervals of outcomes for Mira and Steady groups

Outcome Measure	Mira group	Steady group	Mean Difference	95% CI Lower	95% CI Upper
Mini-BESTest (/ 28 points)	22.80 (2.70)	17.23 (4.38)	5.57	2.29	8.86
TUG (Stopwatch, seconds)	7.622 (1.56)	10.29 (1.84)	-2.67	1.16	4.18
iTUG (BWM, seconds)	7.71 (1.40	10.45 (1.82)	-2.74	1.29	4.19
TUGDT (Stopwatch, seconds)	9.48 (2.29)	15.30 (4.20)	-5.82	2.75	8.89
iTUGDT (BWM, seconds)	9.57 (2.12)	14.97 (3.88)	-5.40	2.56	8.24

Bout counts ≥ 2 mins	65.90 (30.41)	28.92 (18.01)	36.98	15.88	58.08
Ambulatory activity ≥ 2 mins	301.25 (155.80)	121.94 (113.61)	179.31	62.68	295.94
Bout counts ≥ 10 mins	4.50 (6.63)	1.54 (2.90)	2.96	0.13	5.79
Ambulatory activity ≥ 10 mins	69.48 (67.49)	26.69 (53.82)	42.79	-9.75	95.33
Ambulatory activity ≥150 min in bouts ≥ 2 mins	9/10 (90%)	3/13 (23%)			
Ambulatory activity ≥150 min in bouts ≥ 10 mins	1/10 (10%)	1/13 (7.7%)			
ABC (/100%)	88.00 (8.22)	62.23 (28.60)	25.77	6.28	45.26
FES-I (/64 points)	21.80 (3.58)	29.77 (10.76)	-7.97	0.57	15.37
GDS (/15 points)	2.20 (3.26)	2.15 (2.97)	0.05	-2.66	2.77
SF-36 (Global Score, /100%)	75.50 (14.68)	61.38 (20.92)	13.62	-2.57	29.81
FACIT (/52)	45.40 (4.60)	39.23 (10.96)	6.17	-1.44	13.78
MMSE (/30 points)	27.90 (2.38)	27.33 (2.99)	0.57	-1.83	2.97

UTAUT (Mean ± SD of all sub-categories)	5.77 (0.85)	5.69 (0.83)	0.08	-0.68	0.84
PACES (/126)	99.33 (18.89)	107.46 (16.11)	-8.13	-7.50	23.76
FSS (Global Score, /180)	129.78 (28.92)	126.46 (15.25)	3.32	-16.37	23.01

CI = Confidence Interval; TUG = Timed up and go; BWM = Body worn monitor; iTUG = Instumented Timed up and go; TUGDT = Timed up and go dual task; iTUGDT = Instrumented Timed up and go dual task; Mins = minutes; ABC = Activities specific Balance Confidence; FES-I = Falls Effiicacy Scale – International; GDS = Geriatric Depression Scale; SF-36 = Short Form 36; FACIT = Functional Assessment of Chronic Illness Therapy; MMSE = Mini-Mental State Examination; UTAUT = Unified Theory of Acceptance and Use of Technology; PACES = Physical Activity Enjoyment Scale; FSS = Flow State Scale.

Table 5.5 - Descriptive statistics (mean SD) and mean change scores for the Mira intervention group for all outcomes

Outcome Measure	Mira group pre	Mira group post	Mean Difference	95% CI Lower	95% CI Upper
Mini-BESTest (/ 28 points)	19.90 (4.38)	22.80 (2.70)	2.9	-0.52	6.32
TUG (Stopwatch, seconds)	8.67 (2.12)	7.62 (1.56)	-1.05	-0.79	2.89
iTUG (BWM, seconds)	8.83 (2.09)	7.71 (1.40)	-1.12	-0.63	2.87
TUGDT (Stopwatch, seconds)	10.81 (2.60)	9.48 (2.29)	-1.24	-1.11	3.77
iTUGDT (BWM, seconds)	10.94 (2.83)	9.57 (2.12)	-1.37	-1.10	3.84
Bout counts ≥ 2 mins	69.00 (28.01)	65.90 (30.41)	-3.1	-26.45	32.65

Ambulatory activity ≥ 2 mins	320.93 (162.49)	301.25 (155.80)	-19.68	-139.96	179.32
Bout counts ≥ 10 mins	4.88 (3.44)	4.50 (6.63)	0.38	-5.12	5.88
Ambulatory activity ≥ 10 mins	82.01 (69.52)	69.48 (67.49)	-12.53	-56.24	81.30
Ambulatory activity ≥150 min in bouts ≥ 2 mins	7/8 (87.5%)	9/10 (90%)			
Ambulatory activity ≥150 min in bouts ≥ 10 mins	2/8 (25%)	1/10 (10%)			
ABC (/100%)	84.70 (9.03)	88.00 (8.22)	3.3	-4.81	11.41
FES-I (/64 points)	22.70 (3.74)	21.80 (3.58)	-0.9	-2.54	4.34
GDS (/15 points)	2.90 (4.51)	2.20 (3.26)	-0.7	-3.00	4.40
SF-36 (Global Score, /100%)	73.00 (9.23)	75.50 (14.68)	2.5	-9.02	14.02
FACIT (/52)	44.40 (5.13)	45.40 (4.60)	1	-3.58	5.58

MMSE (/30 points)	28.50 (1.51)	27.90 (2.38)	-0.6	-1.27	2.47

CI = Confidence Interval; TUG = Timed up and go; BWM = Body worn monitor; iTUG = Instrumented Timed up and go; TUGDT = Timed up and go dual task; iTUGDT = Instrumented Timed up and go dual task; Mins = minutes; ABC = Activities specific Balance Confidence; FES-I = Falls Efficacy Scale – International; GDS = Geriatric Depression Scale; SF-36 = Short Form 36; FACIT = Functional Assessment of Chronic Illness Therapy; MMSE = Mini-Mental State Examination.

Table 5.6 Descriptive statistics (mean SD) and mean change scores for the Steady intervention group for all outcomes

Outcome Measure	Steady group pre	Steady group post	Mean Difference	95% CI Lower	95% CI Upper
Mini-BESTest (/ 28 points)	14.31 (5.27)	17.23 (4.38)	2.92	-1.00	6.84
TUG (Stopwatch, seconds)	11.07 (4.09)	10.29 (1.84)	-0.78	-1.75	3.31
iTUG (BWM, seconds)	11.89 (4.01)	10.45 (1.82)	-1.44	-1.05	3.93
TUGDT (Stopwatch, seconds)	18.01 (7.74)	15.30 (4.20)	-2.71	-2.24	7.66
iTUGDT (BWM, seconds)	17.83 (7.62)	14.97 (3.88)	-2.86	-1.96	7.68
Bout counts ≥ 2 mins	23.93 (21.90)	28.92 (18.01)	4.99	-10.74	20.72
Ambulatory activity ≥ 2 mins	129.52 (110.65)	121.94 (113.61)	-7.58	-79.68	94.84

Bout counts ≥ 10 mins	1.47 (2.56)	1.54 (2.90)	0.07	-2.05	2.19
Ambulatory activity ≥ 10 mins	24.74 (42.54)	26.69 (53.82)	1.95	-35.50	39.40
Ambulatory activity ≥150 min in bouts ≥ 2 mins	4/15 (33.3%)	3/13 (23%)			
Ambulatory activity ≥150 min in bouts ≥ 10 mins	0/15 (0%)	1/13 (7.7%)			
ABC (/100%)	64.00 (22.22)	62.23 (28.60)	-1.71	-17.99	21.53
FES-I (/64 points)	30.47 (12.71)	29.77 (10.76)	-0.7	-8.53	9.93
GDS (/15 points)	1.86 (2.96)	2.15 (2.97)	0.29	-2.02	2.60
SF-36 (Global Score, /100%)	60.33 (23.68)	61.38 (20.92)	1.05	-16.44	18.54
FACIT (/52)	37.33 (16.07)	39.23 (10.96)	1.9	-8.96	12.76
MMSE (/30 points)	27.93 (1.94)	27.33 (2.99)	-0.6	-1.33	2.53

CI = Confidence Interval; TUG = Timed up and go; BWM = Body worn monitor; iTUG = Instumented Timed up and go; TUGDT = Timed up and go dual task; iTUGDT = Instrumented Timed up and go dual task; Mins = minutes; ABC =

Activities specific Balance Confidence; FES-I = Falls Effiicacy Scale – International; GDS = Geriatric Depression Scale; SF-36 = Short Form 36; FACIT = Functional Assessment of Chronic Illness Therapy; MMSE = Mini-Mental State Examination.

Table 5.7 - Descriptive statistics (mean SD) and mean difference with 95% confidence intervals for sub-categories of the SF-36 questionnaire for Mira and Steady intervention groups

SF-36 categories	Mira group	Steady group	Mean Difference	95% CI Lower	95% CI Upper
Physical Functioning	76.00 (27.26)	52.00 (32.07)	24	-2.33	50.33
Role Functioning/physical	85.00 (31.62)	44.00 (42.30)	41	7.68	74.32
Role Functioning/emotional	83.00 (36.00)	72.00 (41.34)	11	-23.24	45.24
Energy/Fatigue	68.00 (10.59)	56.00 (31.12)	12	-9.45	33.45
Emotional Well-being	78.00 (13.09)	79.00 (24.63)	-1	-16.93	18.93
Social Functioning	85.00 (21.89)	82.00 (33.06)	3	-22.2	28.2
Pain	79.00 (15.95)	66.00 (31.77)	13	-9.91	35.91
General Health	70.00 (7.45)	60.00 (26.05)	10	-7.75	27.75

SF-36 = Short Form 36; CI = Confidence Interval.

Table 5.8 - Descriptive statistics (mean SD) and mean change scores for the Mira intervention group for SF-36 sub-categories

SF-36 categories	Mira group pre	Mira group post	Mean Difference	95% CI Lower	95% CI Upper
Physical Functioning	76.00 (29.23)	76.00 (27.26)	0	-26.55	26.55
Role Functioning/physical	75.00 (35.36)	85.00 (31.62)	10	-21.51	41.51
Role Functioning/emotional	80.00 (28.11)	83.00 (36.00)	3	-27.34	33.34
Energy/Fatigue	61.00 (11.65)	68.00 (10.59)	7	-3.46	17.46
Emotional Well-being	77.00 (10.67)	78.00 (13.09)	1	-10.22	12.22
Social Functioning	85.00 (11.49)	85.00 (21.89)	0	-16.42	16.42
Pain	77.00 (16.75)	79.00 (15.95)	2	-13.37	17.37
General Health	71.00 (10.12)	70.00 (7.45)	-1	-7.35	9.35

SF-36 = Short Form 36; CI = Confidence Interval

Table 5.9 - Descriptive statistics (mean SD) and mean change scores for the Steady intervention group for SF-36 sub-categories

SF-36 categories	Steady group pre	Steady group post	Mean Difference	95% CI Lower	95% CI Upper
Physical Functioning	59.00 (29.23)	52.00 (32.07)	-7	-16.81	30.81
Role Functioning/physical	47.00 (44.19)	44.00 (42.30)	-3	-30.75	36.75
Role Functioning/emotional	60.00 (47.48)	72.00 (41.34)	12	-22.86	46.86
Energy/Fatigue	46.00 (27.02)	56.00 (31.12)	10	-12.58	32.58
Emotional Well-being	67.00 (18.91)	79.00 (24.63)	12	-4.93	28.93
Social Functioning	79.00 (23.04)	82.00 (33.06)	3	-18.9	24.9
Pain	66.00 (26.82)	66.00 (31.77)	0	-22.75	22.75
General Health	59.00 (21.38)	60.00 (26.05)	1	-17.42	19.42

SF-36 = Short Form 36; CI = Confidence Interval

Questionnaires pertaining to flow, physical activity enjoyment and technology acceptance were administered to the intervention groups following the 6-week training period.

5.2.3.5.9 Flow

At follow up assessment, the Mira group appeared to have experienced more flow during the exergaming training sessions when observing the global FSS score with the Mira group 3.32 points (-16.37 to 23.01 95% CI) higher than the Steady group. When observing the individual categories of the FSS, the intervention groups had similar states of flow across the flow categories. The Steady group scored marginally higher in the flow categories representing perception of Action-awareness Merging, Clear Goals, Unambiguous Feedback, Concentration on task at hand and sense of control. The Mira group scored marginally higher in the flow categories representing perception of Challenge-Skill balance, Loss of self-consciousness, Transformation of Time and Autotelic Experience (Table 5.10).

Table 5.10 - Descriptive statistics (mean ± SD) for flow experience subscales (FSS) between the Mira and Steady intervention groups

Flow categories	Mira group	Steady group	Mean Difference	95% CI Lower	95% CI Upper
Challenge Skill Balance	3.78 (0.86)	3.28 (0.49)	0.5	-0.099	1.099
Action-Awareness Merging	3.36 (0.90)	3.48 (0.15)	-0.12	-0.405	0.645
Clear Goals	3.94 (0.74)	4.05 (0.06)	-0.11	-0.315	0.535
Unambiguous Feedback	3.64 (0.89)	3.65 (0.24)	-0.01	-0.526	0.546
Concentration on task at hand	3.69 (0.97)	4.05 (0.31)	-0.36	-0.235	0.955
Sense of Control	3.14 (0.72)	3.40 (0.24)	-0.26	-0.184	0.704
Loss of Self-consciousness	3.47 (1.26)	3.45 (0.24)	0.02	-0.72	0.76
Transformation of Time	3.42 (0.91)	3.30 (0.36)	0.12	-0.458	0.698
Autotelic Experience	4.00 (1.03)	3.73 (0.26)	0.27	-0.346	0.886

CI = Confidence Interval

5.2.3.5.10 Physical activity enjoyment

Perceived physical activity enjoyment was measured at follow up assessment for the two intervention groups. The overall perceived PACES scores showed high levels of physical activity enjoyment for both intervention groups. There was a greater level of perceived physical activity enjoyment for the Steady group by 8.13 points (-7.50 to 23.76 95% CI) more than the Mira group. It was not possible to administer the PACES questionnaire at baseline due to the way in which the questions were phrased. A study comparing the PACES with a shortened version known as the PACES-8 supports this statement (Mullen et al., 2011). Mullen et al (2011) compared two modes of exercise for older adults and found the benefits of resistance exercise and aerobic exercise to be equally beneficial in increasing perceived PACES outcomes. The social benefit of the Steady group taking part in a group based balance activity may have influenced the results observed in the PACES questionnaire. The Mira group may have increased perceived enjoyment due to the exergame itself. It should be noted that self-report questionnaires are highly subjective and perceptions may change with no underlying reasoning based on an individual's mood. For a future RCT it would be of use to use the modified PACES questionnaire as it is shorter and may expedite clinical assessment and reduce participant burden (Mullen et al., 2011).

5.2.3.5.11 Technology Acceptance

It is important to begin by stating that both interventions appeared to find their given intervention beneficial. The results of the intervention acceptance are also supported by the levels of attendance and consecutive visits to the training sessions. When comparing technology acceptance (UTAUT) at the subscale level, the Mira group scored higher for Performance Expectancy, Effort Expectancy and Self-Efficacy, whereas the Steady group scored higher for Social Influence, Facilitating conditions and Behavioural Intention. Although it must be noted that the results were similar for both intervention groups. An interval estimate of the difference between two population means was conducted to compare means between the two intervention groups for the sub-scales of the UTAUT. Differences between the intervention groups and 95% confidence intervals are presented in Table 5.11.

Table 5.11 – Descriptive statistics (mean ± SD) for technology acceptance subscales (UTAUT)

	Mira group	Steady group	Mean difference	95% CI	
Performance Expectancy	6.03 (1.11)	5.92 (1.26)	-0.10	-0.98	1.2
Effort Expectancy	5.67 (1.02)	5.17 1.44)	-0.49	-0.67	1.67
Social Influence	5.67 (1.08)	5.79 (1.38)	0.12	-1.03	1.27
Facilitating Conditions	6.04 (0.81)	6.38 (0.68)	0.35	-0.32	1.01
Self-Efficacy	5.56 (1.09)	5.13 (1.02)	-0.42	-0.52	1.38
Behavioural Intention	5.74 (1.24)	5.97 (1.40)	0.23	-0.98	1.44

CI = Confidence Interval

An important point to note is the understanding of the questionnaire and the method in which they were completed. Individuals in the Steady group had a lack of assistance during administration of the questionnaires, which could have influenced the result. Follow up interviews were conducted with several of the participants following each intervention and the outcomes are discussed in chapter 6.

5.2.3.6 Adverse events

No adverse events occurred during any of the training or assessment visits during the intervention, however, one participant (Mira group) slipped on a wet surface whilst in a supermarket which inadvertently resulted in a fall to the floor. The participant reported no discomfort or pain two days after the event and continued to participate in the study. No serious adverse events occurred. Less than 3% of recruited participants sustained an adverse event during the intervention period, which is 7% less than the progression criterion.

5.2.3.7 Sample size

The sample size was performed on the resultant Mini-BESTest outcomes in the pilot intervention. The projected number of participants needed for a full RCT with three arms, based on an "A prioi" power calculation that computes required sample size with the given alpha, power and effect size for the statistical test of repeated measures ANOVA within-between interaction would be 93 participants. This would equate to 31 participants per study arm. The actual power of the study will be 0.95.

5.2.4 Discussion

We implemented phase 2 of the MRC framework for complex interventions which was a pilot intervention in the community to assess the feasibility of exergaming to improve postural control for community-dwelling older adults. The pilot intervention provided the opportunity to estimate important parameters necessary to design a full definitive trial in the future. All four progression criteria were succeeded which holds promise for progressing to a definitive trial. Specifically, 69% of eligible participants were screened and allocated to the intervention, with a retention rate of 95.7% for all assessments. Adherence rates to training visit completion for both groups were 100% successful although this does not account for consecutive visits (Mira, 98% and Steady, 27%), which prolonged the data collection period. Improvements in postural control were observed at follow up assessment for both intervention groups as measured by the Mini-BESTest, which was administered effectively in all locations with an average administration time of 23 minutes. Instrumenting the 14th task of the Mini-BESTest (TUG and TUGDT) was successful and differences were observed between timing the tasks using a manual method (stop watch) versus timings collected using a BWM. Implementing the BWM to quantify physical activity outcomes at baseline and post assessment was successful. The programming fault by the assessor at baseline highlights the need for more assessors for a full RCT in the future. Overall, the successful use of a BWM during the pilot intervention offers insight into implementing this method of monitoring physical activity objectively using a BWM. Self-report assessments were completed by most, yet, via alternative methods between the groups (at home versus in a laboratory). A parallel administration process is advised for implementation in a future trial. One adverse event occurred during the intervention period which was within the progression criteria of less than 10% of all participants and the adverse event was not serious and the participants recovered immediately. The intervention stage of the pilot intervention can be deemed “feasible enough to continue with modifications” (Craig et al., 2008) to the protocol as although all progression criteria was met, there are several lessons to be learned and that need to be considered prior to the implementation of a full definitive trial.

5.2.4.1 Lesson learned

Differences were observed in several of the processes leading up to, during and following the intervention which must be addressed prior to implementation of a RCT. Behaviour change interventions aim to match all content other than those being compared as an alternate therapy for effective change (Abraham and Michie, 2008). As the pilot intervention was part of a PhD programme, there were several constraints that prevented replicating similarities in the intervention groups. Differences in the recruitment process and intervention design such as content, delivery and intensity must be revisited in the protocol prior to implementing a future definitive trial.

It was not possible to alter the design or recruitment strategy of the Steady group to match that of the Mira group, which may differentiate the reach of the interventions to older adult fallers living in the community. No participants were referred to the Mira and Control groups, yet individuals were either self-referred to the Steady group, referred by a GP or the FASS, which meant individuals were expecting to receive some form of balance training following a fall. This could pose as a potential barrier to randomisation in a future trial as participants could refuse to be randomised to a ‘no exercise’ control group after sustaining a fall, even if a follow up programme is promised. Although not a prerequisite for feasibility trials (Eldridge et al., 2016b), the ability to make judgement on whether participants would be willing to be randomised in a future definitive trial is important to understand if the intervention is possible. The inability to test randomisation procedures opens up the results of the preliminary data of the primary outcome measure to selection biases. Methods are proposed for a future definitive trial with an internal feasibility element to test the procedures of randomisation. It is proposed to use a sequence generation from a computerised random number generator, randomising by stratification to ensure balanced participant characteristics at baseline, randomise to groups using a generated allocation schedule assigned externally to an individual or organisation to ensure concealment allocation, strive to separate the individuals involved in the generation, allocation and implementation of assignments to prevent bias.

Intervention volume was accounted for between the two balance training groups, yet the duration and frequency differed in which the Mira group attended sessions twice weekly for 30 minutes as opposed to Steady completing 60 minutes once, weekly, which totalled 6 hours training time altogether for each intervention group. Although the systematic review conducted (Chapter 2) had reported similar doses of exercise in exergaming interventions (duration range 5 to 20 weeks, frequency 1 to 3 times per week of 30 to 60 minutes training) (Tahmosybayat et al., 2017), the future trial must equate to the recommendations to effectively reduce falls (6 months, 2 hours per week, total of 50 hours) (Sherrington et al., 2011). The Steady group had access to a 30-minute educational discussion each week immediately following the training session, which provided the group with information on acute risk factors for falls and fall prevention and were offered this information on sheets to take home, which the Mira and Control group were not. The educational content for the Steady group is recommended to improve problem solving skills and overcome barriers in the community (Hedley et al., 2010, Rubenstein, 2006). This may have influenced their perceptions on falls and may potentially bias assessment outcomes in the future pilot trial if not administered to all intervention groups. It was also the intent to conduct a one month follow up assessment following the six-week intervention period for all groups to gain insight into any retention of the preliminary effects, however, the length of the Staying Steady programme was 20 weeks and therefore was a pragmatic testing limitation.

One of the objectives of the pilot intervention with a defined progression criterion (>70%) was to assess the completion rates of assessments, which was deemed successful albeit the two erroneous instances by RT at baseline. As the completion of questionnaires differed between the groups (some during the assessment session and some at home) it was not possible to estimate completion times. This also resulted in one participant failing to complete one questionnaire at baseline for the Steady group. This could have implications for assessment completion rates if not considered in the protocol and supports the notion of administering questionnaires at the assessment location as opposed to taking the questionnaires home to be completed. A potential bias that may have affected completion rates was the difference in remuneration between the groups. The Mira group were remunerated for their time and travel to the university yet the Steady or Control groups were not. There was ascertainment bias in that the lead investigator (RT) was responsible for administrating assessments (observer bias), delivering the intervention and analysis of outcomes. For the pilot RCT, considerations must be made to test the relevant blinding of participants, therapists, assessors and outcome adjudicators. It is proposed to alter the recruitment strategy so that participants are recruited with symmetrical outreach methods across the groups. As the Staying Steady programme is already established in the community and has a group based element to balance training as opposed to one-on-one, it may be necessary to recruit individuals via alternative resources such as via age related charities, churches and to advertise in the community for individuals to come to the university on a voluntary basis for a RCT to ensure similarity in the recruitment process of the intervention. This way it is possible to match as many variables of the intervention as possible without compromising blinding procedures. This may make procedures such as recruitment, randomisation, intervention delivery and analysis of outcomes less open to biases.

Preliminary results from the potential primary outcome measure show that postural control had improved in both interventions groups by 2.9 points on the Mini-BESTest which shows equal improvement from baseline. This compares well with the MCID score in a study assessing older adults with imbalances (Godi et al., 2013), and is promising for a future definitive trial whereby the subsequent duration of the intervention would be in accordance with the recommended hours for balance training for falls prevention (Sherrington et al., 2011). The success of implementing a theoretically underpinned balance assessment in an intervention to improve postural control in the community is promising for future identification of balance deficits which pin point the underlying physiological system responsible for the deficit. Instrumenting the 14th task of the Mini-BESTest to support the judgement of the rater and to counter observer bias was a success with 93% completion rate using a BWM. There were slight differences when using a manual method (stop watch) versus measuring timings using the BWM for the Steady group. When assessing the Steady group TUG outcome at follow up assessment, the measurement methods showed a difference of 0.66 seconds longer when measured using the BWM. This difference of roughly half a second may be significant if significance testing was conducted, which could be attributed to the timing at which the assessor tapped the BWM. Having a BWM attached to the participant when undergoing the assessment can be of benefit when aiming to quantify motion objectively, however, the procedure involved triple tapping the device at the beginning and end of each task. This allows for variability in assessment start and end points of the task and it could be argued that the use of a stop watch is more effective as the stop watch is already in the hand of the assessor. If all participants were to complete the TUG at the end of the task, when the buttocks come to rest on the seat, it could be argued that the BWM would be more accurate as the point at which motion stops is more visible from the BWM data, however, this was not the case for all participants and the assessor had to adjust to the circumstances whereby the task had to be stopped and the BWM had to be triple tapped prior to the participant beginning to sit down. This must be considered for the future trial as this may be detrimental to the accuracy of timing the task if the BWM is not tapped immediately following the assessment.

We also implemented the BWM over a 7-day assessment period to compare participants physical activity patterns to recommended weekly guidelines. The implementation was a success with 93% of participants adhering to wearing the device over baseline and post-assessment. Preliminary data shows that when accumulating bouts of 2-minute activity, the Mira group were more active than the Steady group. The number of bouts of 2-minute activity was greater than bouts of 10-minute activity for both intervention groups. When accumulating bouts of 2-minute activity, participants in the Mira group met the recommended guidelines, however, this decreased when accumulating 10 minute bouts of activity and this was reflected in which neither intervention group (Mira 10%, Steady 6.7%, Controls 0%) met the recommended weekly guidelines of ≥150 minutes of moderate physical activity in bouts of ≥10 minute intervals. This value should be considered with caution due to the short trial period, however the results of individuals prone to falls show to be inferior to that of healthy employed and retired counterparts of similar age brackets (Godfrey et al., 2013). The prospect of using BWMs in the pilot RCT to capture physical activity on a weekly basis to track participant progression over 50 recommended hours of fall prevention exercise could prove beneficial to guiding the intervention and tailoring to the needs of the individual.

These study methods may be implemented in feasibility studies and the results from the feasibility indicators may be used to guide future feasibility studies of a similar nature. The results of the pilot intervention may support the feasibility and acceptability of conducting a community based exergaming intervention using Mira™ given the changes to the protocol are considered prior to implementation. The data reflects only the implementation of the pilot intervention for recent fallers and not recurrent fallers, or those with more debilitating conditions. Expansion of the inclusion criteria may enhance the applicability and generalisability to more fall prone populations such as older, frailer adults, yet may require internal nesting of several pilot objectives to ensure acceptance and usability of the intervention.

5.3 Chapter summary

The pilot intervention was implemented and all four progression criteria were succeeded which deemed the intervention feasible "with modifications" to the protocol, which have been proposed prior to implementation of a future definitive trial. The implementation of a theoretically underpinned postural control outcome measure and use of a BWM to assess postural control and physical activity in the community should be considered in future exergaming interventions. The use of Mira™, a tailored exergame to train postural control can be administered to a population of older adults that are beginning to fall on a one-to-one basis, however, matching intervention characteristics between group based fall prevention and individualised training must be considered as well as recruitment strategy and administration of self-report measures prior to implementing a full definitive trial.

6.0 STUDY 3 – FOLLOW-UP INTERVIEWS

6.1 Introduction

This chapter along with the previous chapter forms the second phase of a feasibility study conducted in line with the MRC framework for complex interventions. It will reflect on a pilot intervention assessing the feasibility of exergames to improve postural control in community-dwelling older adults. This chapter is qualitative in nature, although the analysis will systematically explore the perceptions of participants from both intervention groups to provide insight to support the feasibility outcomes of the pilot intervention. The outcomes from this study will assist in informing the implementation of a low cost tailored exergame in the community in a future definitive trial. In this chapter, participants perspective on use and acceptance of exergames will be drawn on as well as their perspectives on other physical and psychological impacts such as balance confidence, fear of falling, fatigue, depression, flow and physical activity enjoyment.

6.2 Perceptions of community-dwelling older adult fallers who undertook a tailored exergame or a community based fall prevention intervention to improve postural control outcomes

6.2.1 Introduction

Falls are a common occurrence among older adults with following circumstances ranging from mild to devastating effects on lifestyle, personal well-being, cognitive and physical functioning (Rubenstein, 2006, Gill et al., 2013). Evidence based exercise interventions with a significant balance component can reduce the likelihood of falls (Sherrington et al., 2011) and are available in the local community in the north east of

England. Yet older adults tend not to seek out care to reduce the likelihood of falling and are often referred to fall prevention classes by the local General Practitioner (GP) or via the Falls Syncope Service (FSS) once a fall has occurred. Those that do attend, fail to comply with home exercise prescribed as part of the programme and adherence to exercise programmes has shown to drop by as much as 50% in the first six month (Farrance et al., 2016). Exergames (exercise games) are a relatively new concept in fall prevention interventions for older adults and have been used to combat decline in adherence and compliance to exercise and balance training programme (Hasselmann et al., 2015). Characteristics of exergaming interventions such as mode of delivery, volume and intensity are heterogeneous. Issues in tailoring and administration of exergames safely for use with older adult fallers remains a challenge, especially for use in complex interventions. Design considerations for exergames focused on improving postural control as a means to prevent falls have been proposed that consider the older adult at the centre of its design (Thin and Poole, 2010, Planinc et al., 2013, Skjaeret et al., 2015). Yet the area has only recently received attention.

A pilot intervention was designed and implemented that compared Mira™ (Mira Rehab Ltd) (Cantea et al., 2017), a low cost exergame for use with older adults to an up and running fall prevention class (Staying Steady) and no exercise controls over six weeks.

This chapter compares and reports on perceptions of older adults undertaking the Mira or Steady interventions. Specifically, acceptance of the intervention and impact on the experiences of the participants were explored relating to depression, flow, well-being, physical activity enjoyment, fatigue, balance confidence and fear of falling. This chapter may provide insight into the details surrounding the design, development and implementation of the intervention going forward to designing a future definitive trial.

6.2.1.1 Objectives of the study

The aim was to explore qualitative reports from semi-structured interviews to gain insight into the acceptability and usability of the Mira and Steady interventions. It was also an aim to explore immersion of participants during Mira or Steady training sessions, the training programs impact on participant's levels of fatigue, depression, fear of falling and balance confidence in the hope to contribute to recommendations for a future RCT.

6.2.2 Methods

6.2.2.1 Design

Individual semi-structured interviews with five participants each from the Mira and Steady intervention groups were conducted to gain insight into facilitators and barriers to future participation in a full RCT. Qualitative interviews have greatly expanded the depth of information gathered when integrated into clinical research in the 1970's (DiCicco-Bloom and Crabtree, 2006). Interviews provide the opportunity to gain insight into phenomenon relating to participants experiences during or following a behavioural change intervention, and has previously guided the design, development, implementation and evaluation of community based interventions for older adults (Sanders et al., 2018). As the research is designed to test a priori hypotheses, a semi-structured interviewing format was used in which the questions and analyses were standardised. This qualitative paper will follow the format outlined in the Consolidated criteria for reporting qualitative research (COREQ) 32-item checklist (Tong et al., 2007) (Appendix Q).

6.2.2.2 Ethics

This study received clearance from the ethics committee at the University of Northumbria at Newcastle (HLS706) (Appendix R). All study participants provided informed consent (See Chapter 5, section 5.2.2.2).

6.2.2.3 Research team and reflexivity

RT led, transcribed and analysed all interview data. Information pertaining to the researcher reflexivity and the research team can be found in chapter 4, section 4.2.2.1 of this thesis.

6.2.2.4 Relationship with participants

RT had established relationships with all participants during the intervention. During the pilot intervention, restrictions in resources meant that RT acted as data collector, outcome adjudicator and interpreter of findings and discussed outcomes with the research team. Participants were aware of the outcomes from this study being used to form part of a thesis. RT and a postural stability instructor (PSI) had briefed participants at the beginning of a fall prevention programme (Staying Steady) the nature of RT attending the classes and RT had briefly explained the nature of the research project prior to participants consenting to participate. Participants were aware that the interview was to gain insight into their experiences and perceptions of their training programmes during the previous six weeks. It is understood that this study is opened up to several biases pertaining to investigator involvement and knowledge of participant performance and outcomes. Several assumptions are identified and stated to ensure transparent reporting of the findings:

- The interviewer was aware of the outcomes of participants following six weeks of balance training (Mira and Steady groups)

- Participants were aware that their responses could be used by the interviewer to inform a research project
- Participants were aware that the interviewer had observed all training sessions and could have prior knowledge of their experiences.

6.2.2.5 Participants

The population of interest were community-dwelling older adults living in the North East of England, UK. Participant characteristics were collected based on age, gender, height and mass (Table 6.0).

Table 6.0 - Participant characteristics divided by group with one-way ANOVA significance tests

	Mira group (n=10)	Steady group (n=15)	Control Group (n=10)
Females to males (ratio)	7:3	13:2	7:3
Age (yrs)	67.6 (63, 85)	76. 7 (68, 83)	71.7 (61, 82)
Height (m)	1.67(0.11)	1.61(0.09)	1.66(0.08)
Mass (kg)	76.0 (16.46)	69.41 (12.91)	72.45 (13.69)

*= presented in counts per group, yrs = years, kg = kilograms

6.2.2.6 Selection

Participants were identified from the two intervention groups. All participants were initially invited for interview and the first five participants from each group were selected by RT. This method was a convenience sampling method and participants were asked on a first come, first serve basis. The sample size of participants at follow up assessment was 32, and the sample size of this study was 10 participants (from a pool of 23 participants across the intervention groups).

6.2.2.7 Data collection

Interviews were conducted in different locations for the two intervention groups. Participants in the Mira group came to a laboratory on specific days for the interview at Northumbria University, UK. Participants in the Steady intervention group came to Deckham Village Hall, Gateshead, UK. There was no presence of non-participants during any of the interviews, no repeat interviews were conducted and participants were not recruited on a data saturation basis. A Dictaphone (Sony Inc.) recorded all audio data for the interviews. RT followed an interview schedule to ask open-ended questions regarding experiences and perceptions, which were based on constructs from the questionnaires administered during the intervention (Table 6.1). The schedule was developed which began by asking some initial questions to gain rapport with the participants. The following questions probed into participants perceptions of usability and acceptance of the intervention, their balance confidence over the intervention period, how immersed they were in their activities during training, their energy levels in a given session and over the course of the programme, any depressive thoughts or sadness that had impacted their experience, if the programme had an effect on their fear of falling and in general their physical activity enjoyment. No field notes were made during the interviews and data was not collected until saturation due to the timeline of the PhD programme.

Table 6.1 – Interview schedule based on constructs from questionnaires administered during the intervention stage of the MirEX study

Questions:	
Initial questions	
1	What are your thoughts on the training program? Did you enjoy it?
2	Anything specific that stood out about the training program? (Favourite game? Favourite movement?)
3	How do you feel after a particular session during the training program?
4	Any aches or pains that have gone away? Have come back?
5	How does this compare to other types of training programs you have been a part of?
6	Did they use movements to drive computer games?
7	Would you do it again?
Acceptance and Usability	
8	What would you change about training program (Exergaming, Staying Steady) console, game) to make it more engaging? (Attitudes)

9	What are your perceptions on safety of using this method (Exergaming/ Staying Steady) to train balance? (Self-efficacy) Were you anxious at all during training? (Anxiety)
Flow	
10	Were you conscious of the movements being conducted during your training session? Where was your attention? Did you enjoy the experience? Worried about performance? Did you feel in control?
Fatigue	
11	How do you feel the training program impacted your level of fatigue? How did this impact your motivation to train?
Depression	
12	Did the training program feel negative in any way in terms of your self-thoughts? (Negative self-talk) Did you feel absent during the program? Could you sleep ok? Slowness of thoughts? Angry?
Fear of falling	
13	Can you tell me how you feel when you go about everyday activities? Are there any fearful moments

	you have or concerns when you are out and about? (falling over)
Balance confidence	
14	How confident are you that you will not lose your balance or become unsteady in everyday outdoor and indoor activities now that you have received some balance training? E.g. Up and down stairs? Standing on a high surface? Escalator in shopping mall? Quick turning?
Closing question	
15	Is there anything else that this training has done for you that you would like to comment on?

6.2.2.8 Data analysis

As the project was restricted to the time constraints of a PhD programme, the audio data from all interviews were transcribed, coded and analysed by RT and discussed with the research team (GB, GW) to triangulate the understanding of outcomes and discuss any discrepancies. Data were uploaded onto a computer and transferred into Nvivo coding software (QSR International Pty Ltd) for analysis. Data were analysed using deductive thematic analysis following six stages (familiarisation; generating initial codes; searching themes; reviewing themes; defining and naming themes; writing up) to systematically explore and organise data into a structured format (Braun and Clarke, 2006). Semi-structured interview questions were formed based on questionnaires participants had completed during the MirEX study (Physical Activity

Enjoyment Scale (PACES), Activities specific Balance Confidence scale (ABC), Falls Efficacy Scale International (FES-I), Geriatric Depression Scale (GDS), Functional Assessment of Chronic Illness Therapy-fatigue scale (FACIT), Flow State Scale (FSS), Unified Theory of Acceptance and Usability scale (UTAUT). Texts within the transcripts were coded by RT whereby participants stated (directly and indirectly) perceptions that spoke to the objectives. Participants are identified by participant number in the texts ("P01EX" for Mira and "P01SS" for Steady). Quotations are presented within the themes to illustrate findings. Participants were not contacted to obtain feedback on the research findings as the Steady intervention group were still attending classes (20-week programme) and this could have biased the feedback with a longer training period.

6.2.3 Results

GB and GW have previous experience in qualitative research pertaining to exergaming and this may help to ensure the credibility and trustworthiness of the findings. No major ambiguities were present between any of the reviewers for themes derived from the thematic analysis. The formulation of a priori questions helped ensure that the scope of the discussion did not drift far from the topics of interest. The established questionnaires from which the questions were formed may have added value to the credibility of the line of questioning during the interviews. The degree to which the data was deemed credible arguably has an impact on the dependability of the data. The planned and executed research design did not change, interview time slots were not rearranged and questions were not amended. Participants did not leave any of the interviews or wish to terminate the session early, which may also support the acceptance of the study design, although this is an assumption and must be taken lightly. After a period of familiarising with the data (transcripts), 127 (58 Mira, 69 Steady) initial codes were generated based on areas of interest that pertained to the questionnaires focus from the intervention and interpretation by RT. Codes were adjudicated by GW and revisited by RT whereby an additional 58 codes (14 Mira, 44 Steady) were added to the list. The codes from both intervention groups were then combined into a single list and initial categories were generated (n=15). The codes and categories were then adjudicated with a third reviewer (GB) before defining, naming and finalising themes (n=2). The two main themes derived and interpreted among the three reviewers were: 1) acceptance of the intervention and 2) barriers to future participation. There were 19 overlapping sub-themes within the two main themes. The sub-themes within theme 1): Positive experience; gained confidence; pain alleviation; repeatable experience; mode of delivery benefits; awareness of exercise; assistance and support; fatigue; falls education. The sub-themes within theme 2): pain; negative thoughts; fear; barriers; negative experience; mode of delivery problems; self-consciousness; personal extenuating circumstances and barriers to attendance. Transcripts are available in Appendix R.

6.2.3.1 Acceptance of the intervention

Both intervention groups reported positive experience's by attending their given programme. Individuals in both intervention groups reported enjoyment whereby the Mira group felt the training was fun, beneficial and although it was exercise, didn't feel like exercise. They reported on their favourite game over the six-week training period which was the functional "Grab" exergame. They felt that the training was challenging, both cognitively and physically, which added to their enjoyment. They felt that the competitive nature of the exergame instigated an intrinsic competitive motivation as the programme progressed.

“It was fun, you know? I’m competitive anyway with myself […] I made an effort to try to beat the score I did before” P02EX

One participant reported having more interest using Mira™ and they were more immersed than when they previously used the Nintendo Wii™.

“I remember my children having the Wii game […] we used to put it on. I have to be honest, I wasn’t interested in that at all but that (Mira™) is different somehow. I don’t know, it just flowed more” P01EX

Similarly, in the Steady intervention group participants appreciated the Staying Steady classes being available. They reported enjoying attending the classes and felt the classes were beneficial, interesting and informative for everyday activities.

“I feel ok. I feel pretty good afterwards […] it’s been explained that it actually helps your joints and your bones which I didn’t realise. I knew it strengthened your muscles but it actually strengthens your bones” P04SS

Participants in both groups reported progressing well over the weeks whereby Steady participants reported the benefit of meeting new people and the group having a positive influence on their experience in the class.

“Yes the friendliness of everybody you know… I’ve got to know a lot of people” P08SS

“Watching someone else […] I think it was good in the group” P05SS

Whereas Mira participants reported enjoying the physical and mental challenge of the Mira™ and how the games were similar to brain training games.

“The ones where you had to get the brain in action […] I was maybe thinking at times, are the other participants doing better than I am” P08EX

“It was challenging and I’m not an advocate of computer games. The only computer game I play is solitaire, that’s all” P07EX

Participants in both intervention groups enjoyed the experience enough to be encouraged to repeat the programme as they reported it motivated them to get back into exercise. Mira participants felt the feedback and the monitoring of the exergame were the motivational aspects to return to the next session.

“The fact that you’ve got the countdown, you’ve got the figures on the screen, which you haven’t got in other types of exercise. I think that was making me more aware of it […] there was that score at the end of each session” P01EX

Participants in the Steady class felt that making the effort amidst other individuals in the class was motivational, increased their want to improve and helped overcome any performance-based barriers during the class.

“No I think a lot of it is positive […] I would say it’s coming here, meeting people, knowing that you’ve got somebody that is helping you to achieve something different and I enjoy it […] I think it’s nice to have something that they look at this type of thing for people, you know, like of our age as well” P01SS

Participants in both intervention groups reported greater feelings of confidence from attending the sessions. Participants in the Mira group reported feelings of balance confidence increase over the 6 weeks in the training sessions, but also in other exercise.

“Well certainly in the Zumba class like I said […] definitely feel more confident yes” P01EX

Participants in the Steady group felt that the classes served as good preparation for situations where they may feel low levels of balance confidence such as getting back up off the floor from a fall. Both intervention groups still felt that they would appreciate more confidence in their everyday activities but it was participants in the Steady group that mentioned more problematic areas such as boarding and exiting public transport.

"My confidence has changed. I'm still nervous about getting on and off buses but it's not as bad as it was. Getting on the metro I just hang on for dear life […] it hasn't stopped me doing it […] it's helped my confidence a bit… but it hasn't taken the problem away, you know what I mean" P04SS

Participants in both intervention groups experienced pain in their muscles at the beginning of the training programme due to beginning a new exercise routine. A more noticeable change in pain reduction was reported from individuals in the Mira group in that they experienced less pain during the training sessions as the weeks went on and in other exercise. Some individuals reported that arthritis pain in the knee had reduced from coming to the training sessions and walking patterns had become normal again.

"Certainly enjoyed it and the osteoarthritis in my knees because of the exercise and that was warming them up and when I was out, I wasn't limping" P02EX

Participants in the Steady group reported loosening of the muscles after a class and that although pain was partially alleviated, pain remained in weaknesses that were a result of a previous injury.

"Yea, because of that fall I still feel that I have that weakness in my right ankle. Not that there would be anything wrong after having broken bones. I feel that it's taken quite a while, you know for it to get better" P01SS

Participants in the Steady group also reported feelings of pain from using Therabands for seated upper and lower body strengthening exercises. Although, participants reported being aware of the benefit of feeling pain during the exercises, attributed to reassurance from the postural stability instructor (PSI), present in the class.

"At the start of the program I felt my arm muscles must have been weaker than I thought […] that was when I started to use the band […] Richard (PSI) was saying that if you use your muscles more, strengthen your muscles in your arms, it helps you push yourself up" P04SS

Participants in both intervention groups felt the sessions were safely delivered and that they didn't feel that the movements were too strenuous beyond their limits. There were benefits and drawbacks to either mode of delivery (one on one versus group class). Steady participants felt initially anxious at the start of the programme being in a group but this quickly dissipated.

"I felt a little bit anxious at first when I didn't know anybody. A little bit yea" P04SS

Participants felt that having the ability to watch and learn from others in the class assisted and motivated participants to put more effort, which improved their learning environment. Having other individuals in the class for the same reasons also felt empathising.

"You try and do the best that you can. I think that's all you can do […] you do have a tendency while you're doing the exercise to look at other people […] I wouldn't mind anybody coming to me and saying… yes you've done something wrong" P01SS

Participants in the Mira group had one on one sessions and only spoke with the instructor. One participant reported that an advantage of Mira over other forms of balance training in a group environment is that the information from the instructor is more personalised. They felt that this mode of delivery compared to say, a yoga class, where the instructor cannot always adjust the pace or difficulty of the class for beginners was advantageous.

"I think it was probably better because you sort of worked into it more gradual, whereas when I have been to a yoga class, the teacher has to take into account new starters but otherwise it's straight into a balance pose" P08EX

Participants felt that coming to the training sessions raised awareness of the importance of maintaining physical activity in old age. One participant from each intervention group also stated the importance of doing exercise other than just coming to the training sessions to maintain good health (P07EX, P06SS). Although there appeared to be awareness of the importance of exercising more within the Mira group. Mira participants were immersed during the training sessions in that they were concentrating on the game and not on the movements they were performing.

"I think you're focusing so much on getting it done in the time that you've got […] less conscious I would say" P01EX

One participant was aware of the movements and the game. Participants were aware of benefit and improvements in other exercise in that one participant likes to run and noticed improved recovery from the run after attending the classes.

"I did and um I thought it was actually quite good for me because of having a weakness in my left leg… so it was very useful in that respect […] I think my recovery is actually better […] because I ran seven and a half miles on Friday and I ran far harder than I should have done […] because I could" P06EX

Participants in the Steady group felt the class environment, demonstration and information from the PSI helped to raise awareness. They also felt that watching others in the class helped to raise awareness and lower anxieties. Participants reported that having the educational element to the class helped raise awareness about themselves, falls specific situations and coping strategies such as slowing down a bit, or lifting the feet more.

"I found it interesting […] I enjoyed the program and learning things that you weren't aware of, you know, like positioning yourself and when you are walking and going around instead of trying to step over. It's interesting watching other people and how they reacted to it" P05SS

Participants felt that their levels of fatigue improved in both intervention groups. Interestingly, participants from the Mira group felt they had a good workout but didn't realise to what extent until after the session. The focus of attention of the games meant they weren't thinking about being fatigued and that they were driven by the gameplay to do the best they could. Participants in the Mira group had noticed improvements in their activity levels in other exercise.

"I would say it improved it […] doing the other classes I could see an improvement and I know that wasn't to do with the class because I was hardly going to the other one […] because that's the trouble isn't it, especially when you're older […] is it really going to make that much difference but I think that can" P01EX

One participant is a member of a walking club and reported walking further distances, which they felt the classes had contributed to. Similarly, a participant in the Steady group that usually used a walking aid to walk longer distances mentioned not taking the "walker" out but instead managed longer distances with just the use of a stick.

"It has improved because at first I felt sometimes a wee bit tired but going off now I don't […] I think it has improved. I know for a fact that I am walking better. I'm definitely walking better […] when I go over to church on a Sunday I just take my stick" P08SS

Participants in the Steady group also reported feeling more energised because of the training programme, although the time of year (winter) meant they didn't go out of the house as much.

6.2.3.2 Barriers to future participation

There were several areas for concern that have emerged from both intervention groups and could serve as potential barriers to participation in a future trial. Interestingly, several opinions on potential barriers are shared between the groups such as fear of falling again, location for training sessions, having personal extenuating circumstances that prevent participation or financial barriers to participation (class versus console). Several participants from both intervention groups felt that location and travel to training was a bit of a nuisance and could be difficult to maintain in a future trial, especially given the number of hours required for falls prevention based postural control training (50 hours).

"Just the bother of waiting for taxis to get home and things like that you know. If it was available and if I could get somewhere nearer really. That's the problem" P08SS

Several barriers exist for future participation that revolve around the mode of delivery. For Steady participants, opinions were expressed about group based barriers such as repeating movements similar to those experienced during a fall, performance concern with others, other appointments and group and movement anxiety. For Mira participants, the barriers were mainly technology based but what also anger was expressed when technological disruptions occurred during training. Participants in the

Mira group felt that the lack of experience with computer games could be a barrier to future involvement in that they would struggle to set up, navigate and troubleshoot the console and games during training. They felt this could potentially stop them using the system if no support was available. Even with support, the repetitive drawbacks of waiting for problematic technology would be demotivating and could impact future adherence to training.

"Yes and you know I suppose the negativity […] the lunges where I felt as though I wasn't achieving […] you were encouraging me and telling me that I was doing the movement correctly. I thought heavens I'm not doing this right" P08EX

Participants on several occasions expressed disappointment when technological drawbacks occurred. Instances where Mira™ would freeze during a movement or game tutorial or the onscreen marker would not follow the correct direction and would invert. Individuals felt that the fault was their own and not the technologies, and even though they were reassured and had the issue resolved by the instructor, they persisted to have negative thoughts about their performance.

"Not always. You know when it doesn't quite go right. It's like "what did I do wrong there?" You feel like you are doing it right but you don't know what you are doing wrong […] I think sometimes it was the setting wasn't quite right. You know you were going to the left and it wasn't going far enough across" P06EX

Participants felt concernment for using Mira™ in the home for several reasons. The intention to use Mira™ in the home or using Mira™ alone brought about barriers of experience in that individuals wouldn't feel confident operating and using the exergame alone. Participants also felt that using the game alone would lose its excitement especially if technological upsets remained during training. Participants also felt that environmental factors in the home such as certain surface types and interruptions during training could be problematic. They felt that certain movements and exergames alone wouldn't be safe if unsupervised and fear could prevent continuation of future involvement. Participants also felt the cost of a training session or buying a console would be influential in whether they continued to use that method to train postural control.

"There is a lot of technology to go in. I would imagine pretty expensive technology for it to be available for a person […] f I came to a centre like this then I'd do it, whereas at home, I can't. Say the phone goes or something happens, the doorbell rings" P07EX

Participants from both intervention groups reported the necessity of having an appointment to personally reinforce the importance of exercising on a weekly basis. Participants in the Mira group felt that having a supervised appointment at an activity centre to use Mira™ would be preferential to using it in the home. They felt that having supervision would alleviate any anxieties for setting up and navigating the console and exergames, or conducting the correct movements during the session.

"I think that would be great, but it would be supervised, would it? […] somewhere like that where people of the same age […] Yes or these sorts of community centre places […] Yea. I think it's something that should be used in the future" P08EX

One participant felt that having an appointment is an incentive to get out of the house, which also maintains human contact and helps avoid social isolation.

"It's been fun, challenging but again as I say… in the home I don't know that I'd do it and I think that it would be pretty expensive to go in a home […] I'd prefer to go to a session where you could maybe… a couple of pounds or something and use it […]

yep just book one of the machines […] you could maybe do it three times a week or something like that" P07EX

Participants in the Steady group appreciated the group element of the class and although had several benefits, one participant reported the need to have more time to perform the movements in the class to see greater benefit and participants felt they required more one on one time with the instructor.

"You know when he tells you to move your feet and stand behind the chair, I feel like I can't move my feet up as high as everybody else but I still move them […] I still would like a bit more" P08SS

Participants in the Steady group also felt that some individuals wouldn't enjoy performing exercises in front of others, which could impact participant compliance and effort during training. In which case, issues of social anxiety could prevent personal improvement and exacerbate fear. Participants in the Steady group reported difficulty in remembering the educational information and the exercises to do at home and there was no contact from the PSI during the week to remind individuals to complete the home exercises.

"Still feel like I'd get probably not as much benefit because I'm not remembering everything he has said you see that's my trouble" P06SS

All participants were keen to repeat the intervention if available. Participants in the Steady group felt that inability to repeat the Staying Steady programme was problematic for future exercise prospects. Participants were aware that towards the end of the programme they are encouraged to find locally based amenities as enablers to maintain physical activity.

"Yes, I would. I'm looking for something, you know, like after this session and I wondered would there be another one, obviously it wouldn't be a repetition of what we've done. I'm looking at something further now" P01SS

However, although acquiring a form of exercise following the programme is beneficial for individual physical activity levels, this may not constitute specific postural control training for fall prevention. One participant in the Steady group expressed how balance training is different to going to the local gym.

P08SS "The exercises we do aren't the exercises you would do in a gym. They are special exercises […] they are focused on balance and confidence".

Similarly, one participants from the Mira group that had previously experienced the Staying Steady programme felt there were important movements missing from the Mira training sessions.

P07EX "On tip toes and standing and holding that. To me they are the better […] and I would have thought that kind of thing would have been on the programme but it didn't have any one legged […] Staying Steady do it on tiptoe and also on your heels […] which is very difficult. Very very difficult".

6.2.4 Discussion

The aim of this study was to explore the acceptability and usability of the Mira and Steady interventions within the pilot intervention. The aim was to explore the acceptance of the training programmes and any impact on participant's fatigue, depression, fear of falling, balance confidence, immersion during training. There were two main themes that emerged from the data and demonstrated similarities and differences across the intervention groups: acceptance of the intervention and barriers to future participation with several overlapping sub-themes discussed within each major theme.

6.2.4.1 Main themes in discussion with the literature

Experiences from participants in both intervention groups were positive overall and the pilot intervention was deemed acceptable by the participants on the whole, yet, the drawbacks were highly dependent on the mode of delivery (one on one exergaming versus group based class). Technology-based barriers were the main barriers to participation in the Mira group whereas barriers in the Steady group were attributed to movement or group-based anxieties and fear of falling. Participants in both intervention groups felt pains alleviate as the programme progressed, although, some pains remained over the short intervention period. This is consistent with an earlier systematic review that reported a lack of evidence to support the use of exergames to fully alleviate chronic pain (Collado-Mateo et al., 2018). An advantage observed in the Mira group was that although participants felt pain, their attention was on the exergame, which helped avoid negative experience during training.

The association of self is an important factor when undergoing an intervention. Future-oriented representations of the self can both positively and negatively impact performance (Ruvolo and Markus, 1992). Most participants in the pilot intervention associated themselves within the category of older adults that need to maintain physical activity in order to stay healthy. Yet, the Steady group appeared to associate more with being “fallers”, yet were aware the training was beneficial. The essence of a fall prevention class draws attention to the fall situations, which can be beneficial but the Mira group participants mainly reported playing games and having fun. Participants in the Mira group were also less informed regarding fall prevention advice during the pilot intervention compared to the Steady group which could explain less association with being a “faller”. Research previously offering older adults fall prevention advice (but no accompanying balance-based exercise intervention) have seen advice rejected deemed by participants as unnecessary, inappropriate or irrelevant. It appears that the association being a “faller” can prompt negative connotations of personal lifestyle management, promote excessive awareness of physical limitations and safety over dignity, identity and autonomy (Yardley et al., 2006). This reiterates the importance of a thorough educational component to accompany fall prevention interventions with emphasis on constructive behaviours rather than defensive prevention, or “taking precaution whilst striving for independence” (Hughes et al., 2008).

Participants undertaking the Mira intervention reported enjoying the intervention, felt energised and had increased levels of balance confidence. These feelings contributed to an increased level of intrinsic motivation and conscious appreciation and a want to progress quickly and effectively during the trial. This finding is in agreement with outcomes from a recent study exploring motivational determinants of exergame participation for older adults in assisted living facilities in that participants are intrinsically motivated to participate in exergames due to enjoyment experienced during gameplay and perceived improvements in physical and mental health, and additionally gained social confidence (Meekes and Stanmore, 2017). As the participants in the pilot intervention trained in individual sessions with an instructor, the only social benefit was that of a personalised nature with the instructor.

Participants in the Steady group also enjoyed the training programme, although for different reasons. There were advantages and disadvantages to the group-based method to train postural control as a fall prevention strategy. Several participants reported the encouragement from the PSI and had the ability to watch and learn from others in the class, in which the Mira group did not. Previous research has shown the benefit of social interaction as an important aspect of using exergames for fall prevention and the importance of setting up exergames with a social component with the instructor and other participants in order to avoid social isolation, which has shown to influence physical activity adherence (Brox et al., 2011). However, participants also reported feelings of anxiety in the group dynamic. Social interaction can also interfere with immersion during exercise because of other individuals in the vicinity when training (Schutzer and Graves, 2004). Steady participants reported not enough time in the classes to practice the movements and would have valued more personal assistance from the PSI. Mira™ offered an alternative in this regard in that individuals using the system were presented with a virtual instructor that offered instruction to correct movements during the exergames. Previous research using Mira™ has reported the influence of the real instructors supervising participants and motivating individuals during the sessions (Meekes and Stanmore, 2017), which was another outcome of this study. The difference being that individuals in the Mira group had both a real world and virtual instructor and the Steady group had one instructor for 15 to 20 participants. The potential to use Mira™ in a social situation whereby individuals can take turns at the exergames or alternatively alone, if desired, opens up the option for both group based and single based exercise programmes. This may offer an alternative mode of postural control training depending on the mood of the individual undertaking training, and be adapted in situations where floor space is insufficient for group based classes. Participants from both intervention groups mentioned the need for more locally-based sessions as travel was an inconvenience. The ability to transport Mira™ into the community due to the minimalist equipment required for gameplay provides a strong opportunity to promote the use of exergames in local village halls or exercise centres that provide adequate space (2m length by 4m width) and supervision.

Mira group participants did report several technology-based barriers which could impact future participation. None of the participants felt confident to set up the system and operate the system alone. Research has already begun to conquer such barriers to setting up Kinect™ based exergames such as a prototype quick start guide that provides information on getting started, troubleshooting tips, and common gestures depicted through images, diagrams, and text (Harrington et al., 2017). There were additional technological disruptions during gameplay such as inverted movement tracking and game freezing which allowed individuals to self-blame, which negatively impacted their experience in the form of negative self-talk and questioning their own capability. Although participants were reminded that the fault of the technology was not their own by the instructor, which relieved the situation, yet some participants did not experience some games and movements due to poor tracking. The technological faults of the game were attributed to using a dated Kinect™ sensor (version 1.0) on updated software (Mira™ platform). This holds promise for a future trial in which an updated Kinect™ sensor (version 2.0) or an alternative can be implemented.

6.2.4.2 Limitations

The scope of acceptance of the pilot intervention may be limited to the individuals that either volunteered or were referred. The outcomes were highly linked with the questions being asked and the deductive manner in which the data was analysed. This may not be transferable to contexts, situations and populations outside the scope of this thesis. All individuals involved in this study were healthy adults, although medical information was not obtained. The perceptions of the participants involved in this intervention may indeed differ to individuals that may have diagnosed and more detrimental health conditions such as Parkinson's Disease. In order to provide transparency in the design of this study, RT has provided key information on the number of organisations taking part in the study and where they are based, the number of participants involved in the fieldwork, the data collection methods that were employed and the number and length of the data collection sessions. There may be issues of reflexivity in that the relationships established with the participants may have bias the views RT had on the outcomes from the data. This was countered with the two co-reviewers of the manuscripts and coding stages of the data analysis. The lack quantitative methods to support the qualitative statements from participants could pose as a limitation to the outcomes from the interviews. A synchronisation of the data may provide more scope to support or indeed refute statements made by the participants. A further limitation of the study was the selection of individuals invited for interview as the researcher decided on the participants to invite. This method is very easy to carry out with few rules governing how the sample is collected, yet may under or over represent a particular group within the sample. This incurs a bias on the transferability of the data as the sample may not represent the population being studied. The low cost and ease of use of convenience sampling method suited the financial and time constraints of the PhD. Although steps were taken to prevent bias, potential selection biases may exist due to the way in which participants were selected for the pilot intervention. Lack of randomisation in the pilot intervention could have already biased the perspectives. For example, the method in which individuals were recruited differed. Steady participants were referred from the healthcare sector whereas Mira participants volunteered from a university database. Volunteering is often decided by the individual in a positive state of mind whereas being referred is similar to a necessary circumstance to improve an outcome. The small sample size of participants interviewed may hold as a dependability limitation to the research in that the minority views of participants in a local community in the north east of England may be of specific backgrounds and may have similar views in this regard.

6.2.4.3 Future considerations for a RCT

Participants generally felt that Mira™ was beneficial to train postural control and aid fall prevention. A prospective RCT can provide the opportunity to apply Mira™ in a group-based scenario in the community to compare similar modalities as opposed to the one on one versus group delivery in the pilot intervention. The ability for participants to navigate the system is an ever-important factor to consider when implementing exergames into the community and the implementation of a more “hands on approach” for participants to set up navigate and monitor their own progression (with assistance) may offer more autonomy, understanding and a more insightful experience. The use of a quick start guide would be beneficial for individuals using Mira™ in a future trial. Interventions should strive to replicate similarities in all other components of the intervention other than that being proposed as an alternative therapy. This includes support and education to ensure equal awareness of a topic surrounding a condition.

6.3 Chapter summary

Mira™ exergames appear to be a promising low-cost alternative to train postural control in the community as a means to prevent falls for older adult fallers. Mira™ motivates older adults to adhere to training programmes and monitors progression in a quantitative fashion (Statistical feedback at the end of games). The improved adherence to exercise could show in other areas of health that are one of the many affected by volume and intensity of exercise. Applying a low cost exergame as an alternative tool may provide more return on investment for physiotherapy based fall prevention programmes in the community and helped release financial pressure on healthcare services. We propose several implications to implementing a future definitive trial in the discussion chapter of the thesis.

7.0 GENERAL DISCUSSION AND OVERALL CONCLUSIONS

7.1 Introduction

This chapter will discuss and synthesize two phases of research that formed a feasibility study of exergaming to improve postural control for community dwelling older adult fallers, using the Medical Research Council (MRC) framework for complex interventions. Following the MRC framework, the first phase consisted reviewing the existing evidence, which included two systematic reviews of the literature, one of which included a summary of exergaming characteristics and meta-analyses of the effect estimates of exergaming interventions, categorised by outcomes of postural control and associated outcome measures. The second review consisted of an analysis of the movements trained in exergaming interventions in conjunction with a theoretical framework for postural control, creating a movement rating scale to explore what is currently trained. The final stage of phase 1 was a qualitative study to explore the perceptions of exergames among different age groups and how that may impact the intention to use exergames for older adult fallers. The outcomes from phase 1 were collated to inform phase 2, the implementation of a pilot intervention in the North East of England, exploring the feasibility of implementing a tailored exergaming intervention in comparison with a traditional balance training intervention and individuals undertaking no intervention to improve postural control for community-dwelling older adult fallers. The pilot intervention was followed with a final qualitative study to gather perceptions of individuals that undertook either of the active interventions. This chapter will discuss the main findings of the thesis and synthesize the evidence from both phases including support and reasoning for progressing to a future definitive trial.

This thesis has provided novel insight into the feasibility of exergaming to improve postural control in community-dwelling older adults. The implementation of the pilot intervention was deemed successful in that all four progression criteria outlined were succeeded. Specifically, 69% of eligible participants were successfully recruited into the study, which succeeded the 50% progression criterion. Adherence to training sessions was 100% successful, which succeeded the 70% progression criterion by 30%, which can be supported by perceptions of enjoyment of the interventions in the follow up interviews. Assessment visits were completed by 95.7% of participants, which included novel methods to assess postural control and physical activity in an exergaming intervention and this progression criterion (>70%) was succeeded by 25.7%. Only 3% of participants (one participant) sustained adverse events throughout the duration of the intervention, which was not sustained during any of the training or assessment visits and did not lead to a serious adverse event (hospital admission) and this progression criterion was succeeded by 7%. With all four progression criteria succeeded, the intervention was deemed successful with modifications to the protocol before progressing to a definitive trial.

Mira™ was well received by participants and motivated individuals throughout the intervention, observed by the lead researcher and reported in follow up interviews by the participants. Preliminary outcomes of postural control, balance confidence and fear of falling improved as measured by the Mini-BESTest, ABC and FES-I scales, and more so in the Mira group. Physical activity outcomes also improved over time and more so in the Mira group. Interestingly, the participants in the Steady intervention group were prompted each week on the importance of performing home exercise as part of the Staying Steady programme or maintaining exercise outside of the sessions, yet, showed low levels of physical activity bouts extending more than 10 minutes and failed to meet the recommended guidelines (150 minutes). There appears to be a general lack of guideline adherence in terms of physical activity as the Control group failed to meet the guidelines at all and the Mira group, although showed to be the most active, only two participants out of ten met the guidelines. The outcomes from this thesis also provide potential for exergames to have an effect on surrounding areas of an individual's lifestyle related to exercise, such as health and well-being, fatigue, depression and cognitive impairment, although, this warrants further investigation in a full randomised control trial (RCT). The application of technology acceptance (UTAUT) and flow (FSS) in this thesis shed light on the perceptions of the sample population and the importance of implementing these models throughout the development of exergaming interventions. Global scores and several sub-scales of the UTAUT were greater in the Mira group and holds prospect for use in a full RCT for evaluating behavioural intention to use exergames. This chapter synthesizes the findings from two systematic reviews, a focus group study, the pilot intervention and follow up interviews and discusses the potential for Mira™ to be used in a future RCT in the community. The thesis limitations will be discussed and potential directions proposed for future research to more effectively implement exergames to improve postural control in community-dwelling older adult fallers.

7.2 Aims of the thesis

This thesis was concerned with exploring the feasibility of implementing exergames in the community in order to improve postural control outcomes to aid fall prevention for community-dwelling older adult fallers. This thesis had the following primary aims developed from the initial research question:

6) To systematically review the literature and perform a meta-analysis of exergaming interventions versus traditional balance interventions and no intervention for community-dwelling older adults, in conjunction with a framework for postural control.
7) To systematically review the literature for movements trained in older adults during exergaming interventions that are associated with a framework for postural control.
8) To investigate the usability and acceptance (behavioural intention) of exergaming, and explore any initial age-related differences in perceptions of exergaming to train balance.
9) To investigate the feasibility of delivering a low-cost, pilot intervention of exergaming versus traditional balance training and no intervention in the community for older adult fallers.
10) To explore the perceptions of the target population to provide feedback on the intervention and the intention to use exergames to train postural control.

7.3 Synthesis of the findings

There were several main findings of this thesis. The preliminary research in phase 1 leading up to the pilot intervention provided evidence on the existing characteristics and effects of exergaming interventions to improve postural control for community-dwelling older adults. Based on the available evidence, exergaming interventions are equally effective at improving postural control outcomes, however, the evidence indicated that exergaming interventions are still very much in the early years of development with relatively few RCTs available. There was heterogeneity in intervention delivery with regards to intervention volume, intensity and mode of delivery and exergaming interventions in the review had an average of 13.5 training hours, which is remarkably lower than the recommended 50 hours necessary in exercise interventions to prevent falls (Sherrington et al., 2011). The review of the evidence of the quality for outcomes of postural control was assessed using the GRADE approach. For each of the outcomes, which are established outcomes as part of a framework for postural control (SFPC), were of low quality and had serious concerns for risk of bias, indirectness, imprecision of the effect estimates and high levels of methodological heterogeneity. The Systems Framework for Postural Control (SFPC) has previously been used to identify components of postural control included in standardized balance measures for adult populations (Sibley et al., 2015). Sibley et al., (2015) concluded that several standardized balance measures provided only partial information on postural control and omitted important components of balance related to avoiding falls. Using this approach, the systematic review highlighted that important information relating to postural control such as how an exergaming intervention affects reactive postural responses (reactive postural control), the internal perception of vertical (verticality) and the influence of cognition on postural control was not assessed. Categorizing the method of postural control assessment into meta-analysis also highlighted that the choice of measure or measures may limit the overall interpretation of an individual’s balance ability, which agrees with the conclusions from the earlier work of Sibley et al., (2015). Not only is there a greater need for more RCTs of greater quality at the study level, but exergaming interventions are missing the evaluation of important information pertaining to postural control at the outcome level (Horak et al., 2009, Franchignoni et al., 2010). Only after the improvements in quality and validity of exergaming intervention design, can the literature provide more accurate evaluations of effect estimates to guide decision making at the population level. A decision from the findings of the first review was the selection of the potential outcome measure for the pilot intervention, the Mini-Balance Evaluation Systems Test (Mini-BESTest), for its ability to provide a more comprehensive assessment of dynamic postural control, with a similar administration time as a traditional balance scale such as the Berg Balance Scale (BBS) (Berg, 1992). The difference being that the Mini-BESTest was able to target specific postural systems underlying balance deficits and assessed postural responses to perturbations, standing on compliant and inclined surfaces and walking with a cognitive task. Limitations with traditional rating scales have shown ceiling effects in higher functioning older adults when assessing minimal detectable change scores (Yelnik and Bonan, 2008, Pardasaney et al., 2012). The practicality of using rating scales in the community is of value, however, the inability to predict future concerns in higher functioning older adults shows that alternate methods are required to be able to distinguish between the high functioning older adults, high functioning fallers and their low functioning counterparts. Several studies in the review implemented additional methods to provide a more detailed assessment of postural control (Pluchino et al., 2012, Lai et al., 2013, Merriman et al., 2015, Whyatt et al., 2015). To date, no exergaming intervention has used the Mini-BESTest (Franchignoni et al., 2010), a rating scale designed to assess dynamic postural control and underpinned by the Systems Framework for Postural Control (SFPC) (Horak et al., 2009). It's ability to discriminate between fallers and non-fallers and has previously proved its reliability, validity and responsiveness as a measure with high clinical utility (Potter and Brandfass, 2015). Assessing dynamic balance, the Mini-BESTest assessed eight of the nine components of postural control in conjunction with the SFPC (Sibley et al., 2015) and it has shown to have wide applicability to many individuals with imbalance (Potter and Brandfass, 2015, Padgett et al., 2012, Tsang et al., 2013, Leddy et al., 2011, King and Horak, 2013, Duncan and Earhart, 2012, Mak and Auyeung, 2013). Although there are variations in the literature about scoring, one study observed a floor effect for lower functioning individuals in rehabilitation settings (Roaldsen et al., 2015) and there is limited data due to its recent availability.

A further finding of the review was that no instrumented assessment of postural control was undertaken by use of body worn monitors (BWMs). BWMs have previously been used to directly measure human movement (Godfrey et al., 2008) and more recently have been compared to gold standard (timed) measures for postural transitions (Godfrey et al., 2014). The potential to monitor postural control with the use of an objective measure such as a BWM to track instrumented postural control (Lara et al., 2013) can not only provide objective support for the assessor but can also assess postural control in an individual's residing environment, whereby environmental and task demands differ compared to standardised laboratory assessment (Pardasaney et al., 2013). This thesis aimed to implement a BWM that is community mobile yet provides objective data that can be compared to specialist laboratory based equipment, with the advantage of supporting observations of the assessor objectively when administering rating scales. Therefore, the second recommendation from the systematic review was to implement the first use of a BWM in an exergaming intervention to assess postural control objectively whilst administering the Mini-BESTest.

The first review provided existing evidence on the characteristics and effects of exergaming interventions and associated outcomes and measures. It was deemed necessary to conduct a follow-on review to identify the movements that trained underlying systems of postural control in exergames, with theoretical underpinning from the SFPC. This thesis implemented a movement rating scale to assess if all the areas of postural control are being or can currently be trained. This review was also the first systematic review of our knowledge that assessed the movements trained in exergaming interventions and the consoles and exergames used, in conjunction with an established theoretical framework for postural control. The primary outcome from the review revealed that no exergame set up (console or exergame) trained all 9 areas of postural control. The use of commercial “off the shelf” equipment or custom set-ups utilising commercial equipment failed to train important physiological systems responsible for maintaining equilibrium in various sensory and environmental contexts. All of which are all contributing components in multifactorial balance deficits and risk of falls (Horak, 2006). A second finding of the review revealed that exergaming interventions utilising a Kinect™ camera didn’t necessarily outperform the more popular Nintendo Wii™, solely based on instrumentation, but the recruitment of the movements directed to drive gameplay and the complexity of the game screen and game elements made a difference. The Xbox 360™ and Kinect™ camera with exergames “Your Shape − Fitness Evolved” and “Kinect Adventures” trained 7 out of

9 areas of postural control and the Wii™ trained 6 areas on average, with much variability between the individual studies and games. The difference between the two console set-ups being that the Xbox 360 Kinect™ with the above exergames trained more dynamic stability through utilising whole-body movements and multidirectional stepping actions with various game components. The restrictive nature of the Wii™ balance board and failure to incorporate stepping actions onto and off the platform meant the Wii™ only trained static and dynamic balance ability within the base of support (BoS). Whilst this form of training is beneficial to activities of daily living such as reaching for a cup on a shelf, the likelihood of a fall increases once the limits of stability are compromised and the centre of mass moves outside the BoS (Horak, 2006). Whole body movements can often replicate the necessary movements in order to prevent a fall such as compensatory stepping actions once postural stability breaches the base of support. This form of training has previously shown a reduction in falls and falls related injuries by 35% (Robertson et al., 2002). This review also highlighted two areas of postural control not trained; reactive postural control and sensory integration. The demands of the human body to react within 100 milliseconds of receiving a physical perturbation is arguably not practical or safe for use in exergame training for older adult fallers without specialist supportive equipment nearby or additional supervision, which can be costly. Not directly related, but a similar finding was observed when eliciting postural responses from physical perturbation during administration of the Mini-BESTest in a hospital setting, in that the researchers of the study stated that more clinicians may be necessary to safely administer the scale without sacrificing safety of less functioning participants (Roaldsen et al., 2015). Nevertheless, exergames that elicit similar reactions from gameplay (reacting to cues onscreen) may provide more benefit by training the motor response without the

physical perturbation. The second area of postural control not trained was sensory integration. The training of various sensory contexts demands reweighting one or more sensory inputs such as the feedback loops from the visual and somatosensory inputs (Horak, 2006). No studies included in the review provided the ability to close the eyes and play exergames or alter the support surface to elicit a response from proprioceptors in the body. The importance of being able to reweight sensory information from one sensory context to another is a key factor as falls can occur when there is a deficit in one or more of the senses (eyes, ears and body sensory feedback) (Horak, 2006). A recent study found proof of principle evidence in individuals with cerebellar degeneration, a neurological condition of the cerebellum which includes deficient postural control as a symptom, that audio-biofeedback (ABF) of trunk acceleration could be used as a real-time assistive signal to compensate for deficient postural control (Fleszar et al., 2019). They found that auditory cues, are functionally similar to vision in the absence of vision and additive to vision in the presence of vision. This approach could be adopted for use in exergames designed to include elements of gameplay with the eyes closed or on a compliant or inclined surface with auditory feedback, although this warrants further investigation and implementation with supervision.

This thesis aimed to use the existing evidence from the literature to support the development of a pilot exergaming intervention. The first recommendation from the review of the evidence was to use the Mini-BESTest as a primary outcome measure, for use with older adult fallers in the community. The second recommendation was to implement the first use of a BWM in an exergaming intervention to assess postural control in the community as a supportive measure to the Mini-BESTest rating scale. The third recommendation was to utilise the Kinect™ to train postural control for its ability to train static and dynamic postural control within and outside the BoS. The fourth recommendation was to use a tailored exergame that trained movements based on informed guidelines from current best practice and to closely match the movements in the exergame group with that of standard practice (control group) (Barry et al., 2016). The exergame platform we decided to use considers older adults at the centre of its design and incorporates movements based on established balance training programmes, the Otago home exercise programme (Campbell and Robertson, 2003) and the Falls Management Exercise programme (Skelton et al., 2005). Mira™ is an exergame that had a strong cognitive element that was tailored to the older adult's interest, monitored progression and could be reviewed on a regular basis by a clinician via a digital platform of feedback. Mira™ had previously been used for rehabilitation of balance outcomes in a pilot study with a small sample of participants (Verhoeven, 2017) and in a recent research study exploring motivational determinants of older adults exergame participation in assisted living facilities, to improve physical function and reduce fall risk (Meekes and Stanmore, 2017).

Prior to implementing the recommendations from the two systematic reviews, this thesis aimed to explore initial perceptions of usability and acceptance of commercial exergames across adults of various ages to understand any similarities and differences that may exist when using exergames to train postural control. The MRC guidance on designing and developing complex interventions purpose that as part of the development of a complex intervention, it is suggested to interview those targeted by the intervention to gain an understanding of the perceived value and intent to use the intervention. This was the first focus group study to our knowledge that utilising the Unified Theory of Acceptance and Use of Technology (UTAUT) model to gain insight into acceptance of technology and behavioural intention of using exergames to train balance across various age groups. Previous research had used the UTAUT to explore user acceptance highlighting important usage indicators of exergames in younger adults (Barry et al., 2016) and individuals with Multiple Sclerosis (Robinson et al., 2015), yet no research had implemented the UTAUT model to gain insight into behavioural intention to use exergames across various age groups. In essence, behaviours can either compromise (smoking, poor diet) or protect (care-seeking, attending medical screening and adhering to treatments) health related outcomes (Michie et al., 2017). If exergames can be used to motivate individuals to adhere to balance training interventions, then it appears important to understand the intention of adults to use exergames. This study contributed to the evidence by highlighting four main themes, deduced from systematically exploring reports from focus group discussions, led by a priori questions derived from the UTAUT after a short trial with some commercially available exergames. Exergames are generally accepted across various aged adults, although, console and exergame barriers become more apparent with age, which impact intention to use exergames. This preliminary research identified that younger adults did not prefer exergaming as a method of balance training and the younger adults reported that they tend not to train balance in general but prefer other forms of exercise as other means were available to them such as going to classes or the gym. A second finding from the study was that participants young and old found that screen complexity (on-screen object size, and instructions) played an important part in deciding on use (behaviour intention) of exergames, however, younger participants felt that this would impact an older adults' ability to use exergames more so. During the focus group study, Mira™, an exergame tailored for older adults was implemented in the third focus group with older adults in addition to the commercial exergames available on the Kinect™ and the Wii™. The older adults that had trialled the Mira™ exergame felt the pace of Mira™, the instruction and the complexity of the screen was similar to that of the Wii™, was more challenging and balance specific and preferred the equipment free nature of the Kinect™. This clarified the decision to include Mira™ in the thesis as this exergame was deemed more appropriate for older adult fallers and it was necessary to implement Mira™ to understand its impact on technology acceptance and behavioural intention (UTAUT). A further finding of this study was that adults, whether young or old, favoured the opportunity to use exergames to train balance more so with others rather than alone. As exergames were deemed a social activity and fun, which was preferred when shared with others. For older adults to accept and use exergames, it was understood that there must be a social factor, or connection when using exergames, as social connectivity is an invaluable basic benefit of age-friendly community environments (Menec et al., 2011).

The recommendations from phase 1 was the implementation of the Mini-BESTest and a BWM to track postural control and physical activity during the assessment periods of the pilot intervention. The existing evidence also recommended not to use commercially available exergames due to the lack of movements trained during gameplay and various perceived limitations held regarding the screen, lack of instruction and the pace of the game play for older adults. The use of Mira™, a tailored exergame that was designed with rehabilitation at its core, was the exergame of choice to be used in the pilot intervention. Unfortunately, due to the restrictions of the PhD timeline, it was not possible to arrange the training sessions with Mira™ in pairs or groups for the intervention to ensure the competitive nature was upheld during training sessions. However, the digital platform of Mira™ enabled individuals to keep track of their score on a session by session and weekly basis. Thus, implementing the recommendation from the focus group study to maintain a competitive edge during exergaming gameplay.

Phase 2 of the thesis was the feasibility and piloting stage, in line with the MRC framework, consisted of testing the procedures for their acceptability, estimating the likely rates of recruitment and retention of participants for the training sessions and outcomes of interest and calculating a sample size for a future definitive trial. This provided an opportunity to address and uncertainties that were made clear in phase 1 (developmental phase). This consisted of implementing a low-cost, tailored exergame (Mira™) into the local community to assess the feasibility of improving postural control for community-dwelling older adults. The exergaming intervention was compared to a traditional balance intervention in the local community in which members of the public were referred to either of their own accord or by a GP of the Falls Syncope Service (FSS). The exercises used in Mira™ and in the comparison group were based on well-known balance exercise programmes, Otago (Campbell and Robertson, 2003) and Falls Management Exercise (FAME) (Skelton et al., 2005).

The pilot intervention had specific feasibility progression criteria, modelled on the processes of the intervention. The first progression criterion for recruitment (>50%) was succeeded by 19% in that 69% of eligible participants were screened and allocated to the intervention. At the end of the intervention period, 100% of participants completed all training sessions, which was 30% more than the progression criterion (>70%). Although all participants completed training visits, the number of participants completing consecutive visits was greater for the Mira intervention group than the Steady intervention group. The retention rate progression criterion (>70%) was succeeded in that 96% of participants completed all assessment visits. Only one adverse event (3%) occurred during the intervention period, which was deemed non-serious as a hospital admission was not necessary and the participant recovered immediately. This result was less than the 10% progression criterion and did not occur during any of the training or assessment visits.

The percentage of eligible participants recruited in the pilot intervention exceeds that of a self-regulated exergaming intervention in a geriatric rehabilitation setting (25%), whereby 20% of all eligible participants initially dropped out due to not entertaining the idea of exercising with a (prototype) exergame (Fielding et al., 2007). It also exceeds that of a study comparing group based exercise and home-based exercise for urban elderly individuals in a falls exercise programme (31.8%) (Stineman et al., 2011). Other exergaming-based feasibility studies failed to report the percentage of eligible participants recruited (Williams et al., 2010, Bieryla and Dold, 2013, Chao et al., 2013, Grigorova-Petrova et al., 2015, Im et al., 2015).

Previous research has documented adherence rates to physical activity (PA) interventions for older adults as the proportion of participants completing programmes (65% to 86%) and of available sessions attended (58% to 77%) (Picorelli et al., 2014). Adherence to this pilot intervention correlated well with the adoption phase (3 x per week for 8 weeks) of the Lifestyle Interventions and Independence for Elders (LIFE-P) pilot trial (76.3 ± 24.5 %) (Fielding et al., 2007). This pilot intervention also correlates well with a study comparing adherence to class and home-based exercise for urban elderly individuals in a falls exercise programme in that 73% of participants completed the programme (7 classes) (Stineman et al., 2011). The results also compare to a RCT that compared self-regulated exergames with self-regulated exercises using printed instruction leaflets in that 85% of patients in geriatric care completed the scheduled treatment sessions. The exergaming group adherence was inferior to that of self-regulated exercise although the intervention period lasted only 2 weeks and the exergame used was a prototype and although the participants did not experience technological difficulties with the exergame, the sessions were scheduled alone and players could not accumulate points to maintain a competitive edge to the sessions (Oesch et al., 2017). This coincides with a recent systematic review that compared adherence rates of technology-based and traditional exercise programmes for older adults (Valenzuela et al., 2018). Adherence was higher for technology-based interventions rather than traditional interventions for the first 12 weeks of the intervention. Additionally, higher levels of adherence were correlated with greater enjoyment of the intervention. Valenzuela et al., (2018) highlight that more research is needed investigating the prolonged adherence of technology based exercise interventions in populations less able to determine long term feasibility and adherence to these programmes. Adherence to training visits for both groups in this pilot intervention was 100% successful although not for consecutive visits (Mira, 98% and Steady, 27%). Attendance in the Steady group prolonged the data collection period in, which was manageable owing to the nature of the study being a pilot intervention. For a future RCT, matching the characteristics of the interventions such as the volume, frequency and method of delivery (group versus individual) may suggest greater attrition. Adherence to training sessions could also have been affected by the methods of recruitment in that the Mira group participants were selected from a pool of individuals that volunteered in research previously (unrelated to balance training) and the Steady group participants were referred to the fall prevention class by a doctor or a falls clinic. Adherence to exercise interventions for older adults is often promoted with the belief that individuals can improve as long as they have the ability (to an extent) to follow the requirements of the intervention (Picorelli et al., 2014). Self-efficacy, a sub-domain of the UTAUT questionnaire administered to both intervention groups at follow up assessments, was higher in the Mira group, which could correlate with the adherence rate in that individuals had more perceived confidence in their own abilities to accomplish the programme, as well as the nature of game play and enjoyment. There were also noticeable differences in that Mira participants reported health promoting behaviours outside of the balance training sessions (aerobics classes, yoga, running and walking) compared to the Steady group (one participant reported being active everyday), which could be more associated with adhering to the intervention. Previous research has postulated that individuals with other health promoting behaviours have held higher rates of adherence during exercise programmes, which could pose as a marker for personality type (volunteer versus referral) (Picorelli et al., 2014). Interestingly, Mira group participants reported other health promoting behaviours, yet, these statements were not supported by the instrumented assessment of physical activity bouts longer than 10 minutes using a body worn monitor (BWM), which challenges their statements and supports the subjectivity of self-reported measures of physical activity in behaviour change interventions. Participants in a physical activity (PA) group in the LIFE-P programme, that reported more than 150 minutes of moderate physical activity per week, had greater adherence to the latter phases of the trial and performed better on a Short Physical Performance Battery (SPPB) score than those reporting less than 150 minutes per week (Fielding et al., 2007). Adherence to interventions has also previously been correlated with personal factors such as reduced mental well-being, fatigue and depression (Stineman et al., 2011). The importance of encouraging individuals during interventions that suffer greater symptoms of fatigue, depression and mental well-being could influence the rates of adherence (Jancey et al., 2007, Fielding et al., 2007). The Steady group participants had shown lower levels of mental well-being, fatigue and depression (not statistically significant) compared to Mira group participants, which could have influenced their willingness to participate in all group sessions. A noticeable difference between the intervention groups was the strategies to enhance adherence. Mira group participants had immediate feedback during the session relating to point rewards for repetitions of movements conducted within each exergame. They also received an accumulated score at the end of each session which was a target to beat for the next session. This motivational tool could have indirectly promoted adherence to the intervention through intrinsic competition. Steady group participants were not monitored as closely in terms immediate feedback during the classes. The lack of immediate objective feedback during the classes, apart from feedback from the instructor, could contribute to differences seen in the adherence rates overall. Furthermore, Steady group participants were asked to complete the home exercise component of the programme, yet were not given specific goals or targets apart from the recommended number of minutes (30). This relied on self-report documentation of home-based exercise adherence, which again during the week of instrumented physical activity assessment appeared to not meet the recommended guidelines and was poorly adhered to in general.

The primary outcome measure (Mini-BESTest) was successfully implemented, with a mean (SD) administration time of 23.1 (± 5.5) minutes. This is a longer administration time than reported in an appraisal of the Mini-BESTest which stated completion in 10 to 15 minutes (Potter and Brandfass, 2015), however, the additional process of instrumenting the Mini-BESTest with a BWM meant applying and tapping a BWM between each of the tasks which took additional time. Completion of the Mini-BESTest assessment was 91.4%. Participants in the Mira group completed all Mini-BESTest assessments at baseline and post intervention (100% successful) compared to the

Steady (86.7%) and Control (90%) groups. The Mini-BESTest, although only assessing dynamic balance (4 of the 6 domains of the SFPC) has recently been identified as more accurate than the BESTest, the Berg Balance Scale (BBS) and the timed up and go (TUG) at identifying older adults with a history of falls in values for area under the curve (AUC) (0.84, 0.74, 0.69 and 0.35, respectfully) (Yingyongyudha et al., 2016). This is the first implementation of the Mini-BESTest for use in an exergaming intervention aimed at improving postural control and reducing the risk of falls. The Mini-BESTest assesses 8 out of 9 components of postural control (Sibley et al., 2015). Functional stability limits, is assessed in the BESTest but not in the Mini-BESTest. This is a limitation as the Mini-BESTest is more focused on dynamic postural control. It may be necessary to implement the BESTest or add the Functional Reach Test to the Mini-BESTest in a future definitive trial to provide postural information when standing still and evaluating an individual's limits of stability. As postural control and falls are context dependent, it is important to test the integrity of all the underlying postural systems when diagnosing individuals with balance deficits (Horak, 2006).

A BWM was attached to participants for the duration of the Mini-BESTest assessment. The first systematic review conducted in phase 1 had highlighted that no exergaming intervention had utilised instrumentation to objectively and simultaneously support balance assessment using rating scales. This involved triple tapping the BWM prior to and following each task during the Mini-BESTest for each participant. Due to time constraints of the PhD, only the 14th task of the Mini-BESTest was analysed and compared using a stop watch (standard method of assessment) and was tracked using the BWM (tapping before and tapping following the task). One assessor was responsible for timing using the stop watch and tapping the BWM before and after the task. This may have contributed to inaccuracies in the results between the two methods of assessment for the Steady intervention group. The longer duration of the Timed Up and Go (TUG) for the Steady group tracked by the BWM may include the time taken to approach, locate and tap the BWM on the participants back. Previous research has included instructions to participants to ensure they remain still before and following each task to prevent any offsets in the accelerometer signal. In addition to the instructions, video playback was enabled to manually note start and end time of each task, which was deemed the gold standard over the BWM (Godfrey et al., 2014). Participants in the pilot intervention were instructed to remain still before and after each task of the Mini-BESTest, however, some participants simply forgot as their focus was on the next task at hand. This must be considered at the protocol stage of the future definitive trial and it would be of value to record the tasks with video capture to provide additional observation and timing for each task. It has previously been suggested that the Mini-BESTest requires two assessors present to administer the scale safely and effectively (Roaldsen et al., 2015). This also highlights the need for an additional assessor when administering the Mini-BESTest with a BWM attached. The TUG has previously been instrumented with multiple portable inertial sensors to automatically detect and separate the subcomponents (sit to stand, gait, 180-degree turn, and turn to sit) to provide a detailed analysis with higher sensitivity compared to the traditional overall time (Salarian et al., 2010). It may be worth investigating if the the iTUG and iTUGDT can be subcategorized with a single tri-axial accelerometer.

The implementation of a BWM in the pilot intervention to assess physical activity was completed for 92.9% of participants overall, 94.3% at baseline and 91.4% at post assessment (Mira 80% and 100%, Steady 100% and 86.7% and Control 100% and 90%, respectively). Reasons for unsuccessful administration was an error in administration and application of the BWM in the Mira group at baseline by the assessor and attrition for both the Steady and Control groups at post assessment. Participants generally reported the BWM to be unnoticeable during the 7-day period and did not interrupt with normal activities. Only one participant commented about skin irritation and no BWMs were lost during data collection. Several participants reported the tracker dismounting, although, reattached immediately. The reporting of the use of the BWM are in line with recommendations (Freedson et al., 2012). The implementation of the self-report assessments was deemed successful although the FES-I questionnaire was only completed by 14 (93.3%) participants in the Steady group. At post assessment 86.7% and 90% of questionnaire were completed by Steady and Control groups yet the overall implementation of self-report assessments by the Mira group were successful (100%).

The implementation of a tailored exergame was successful, adherence to the training sessions and the perceptions on using Mira™ support its use in a future definitive trial. The development phase of this thesis had highlighted that no commercial exergames trained all of the components of the SFPC, although further investigation via mathematically modelling is warranted to compare the percentage score with effect estimates observed in the meta-analyses. To investigate if the components of the SFPC were trained in the pilot intervention, it was necessary to review the movements in each of the Mira™ exergames used (Appendix M). This was to assess if a tailored exergame, with movements formed using a combination of the Otago home exercise programme (Campbell and Robertson, 2003) and the Falls Management group Exercise programme (FaME) (Skelton et al., 2005) trained all of the components of the postural control. One participant from the Mira intervention group highlighted in the follow up interview that there were movements not included in the Mira™ exergames that they had performed when they took part in the Steady intervention several years prior to the study. These movements were tandem stance and tandem walking, backwards walking and the practice of lowering down to and standing up from the floor. The review of the movements required to drive the exergames, in conjunction with the SFPC, failed to include reactive postural control and sensory integration for the same reasons that the systematic review had highlighted in phase 1. The inability to receive a physical perturbation that requires a postural response (as low as within 100 milliseconds) meant that corrective stepping actions are not strategically implemented. It is unknown how reactive postural control could be implemented into an exergame without an additional individual applying a perturbation. Including exergames with more multidirectional stepping actions does train the necessary motor control to prevent falls (Skjaeret et al., 2015, De Bruin et al., 2010). Exergames do require individuals to react to onscreen cues and Mira™ recorded the speed at which individuals responded to the cognitive elements of the game. For example, the speed at which participants chose the correct colour and not the spelling of a word was recorded. The future trial could use this data to more closely monitor cognitive based improvements. Interestingly, the Steady intervention class also failed to train reactive postural control. The Steady intervention included an obstacle course, which required individuals to complete walking forwards and backwards, which invoked fear in several of the participants, but no sessions were delivered that trained the reaction to a physical perturbation.

There are inherent benefits using a tailored exergame for older adults over commercially available exergames such as the movement's trained, clear instruction, clear progression and monitoring of movements more precisely. However, similarly to commercial exergames, Mira™ could not train sensory integration. The additional support and equipment necessary to safely administer this form of training is expensive and not community mobile. The use of auditory cues in place of visual cues has been recently proposed in a proof of evidence study (Fleszar et al., 2019). This sensory replacement could provide exergame designers the opportunity to deliver some portions of an exergame with the eyes closed, although this may not appropriate for older individuals with superior neurological impairment without sufficient support or supervision.

Technology today, permeates all aspects of human life and has an increasingly important role. Understanding and clarifying the drivers that influence the acceptance of technology can impact future intention to use the technology (Venkatesh et al., 2003). Research has only recently applied the use of the UTAUT in exergames to evaluate technology acceptance in relation to behavioural intention (Robinson et al., 2015, Nawaz et al., 2014, Barry et al., 2016). The research reported in this thesis indicates that older adults beyond the age of 60 years (fallers and non-fallers) intend to use exergames to train postural control if locally available. The implementation of the adopted UTAUT scale was successful with the Mira group scoring higher on two of the main subscales (Performance Expectancy (PE) and Effort Expectancy (EE)) that influence behavioural intention (BI). The results from the administered questionnaire and the follow up interviews points towards Mira participants believing that exergames would be more helpful to achieve postural control training goals (PE) as the system was easy to use (EE) after a short demonstration and would be beneficial to play with partners, grandchildren and friends in the community (SI). Although, BI to use exergames would be more based in the community and not in the home, a more robust RCT is needed to clarify these initial insights. Previous research has assessed older adult's user experience of balance training exergames and identified PE to that affect their intention to use exergames (Nawaz et al., 2014).

Whereby older adult fallers in this thesis clarified the use of exergame to train their balance as being beneficial, which agree with the small amount of literature on PE and exergames available. The Mira group believed the Kinect™ was easy to use, although it must be noted that the instructor present was operating the Mira™ Platform, therefore these claims must be considered in the context of interacting with the Kinect™ sensor only. The implementation of the UTAUT in this thesis has shown preliminary use of such models for predicting behavioural intention to use exergames for postural control training for older adult fallers. The application of the UTAUT in questionnaire, focus group schedule, thematic analysis and semi-structured interview enabled various forms of feedback regarding technology acceptance. The focus group schedule formulated using the UTAUT enabled shared opinions of technology acceptance and how behavioural intention differed between different aged groups. By using the UTAUT model in during the process of deductive thematic analysis, it was possible to interpret shared views on the subscales of the model, align them with the themes and incorporate them into overarching themes which served as a purpose in in understanding differences between different aged users of exergames.

The sense of reward or achievement has previously been linked to motivation to continue an activity and potentially repeat a performance. Flow experience was implemented into this thesis during the pilot intervention to investigate the experience of immersive behaviours of individuals that undertake a group based fall prevention class and an individualised exergaming session. Observations by RT and feedback from participants at the point of collecting questionnaires indicates that participants required more assistance in completing the Flow State Scale (FSS). Several of the statements were reportedly difficult to comprehend and therefore, preliminary results of Flow following the intervention must be taken with caution in this thesis. Participants interviewed from the Mira group following the intervention reported lessened pain, higher concentration, competitive behaviours and enjoyment linked to attention being primarily on the game and not on the movements being conducted. The perceptions from the interviews seemingly contrast with the outcomes from the questionnaires which supports the investigators observations of lack of understanding of the statements of Flow. For the future definitive trial, it is recommended that all questionnaires are further explained including any lack of understanding of the statements involved. This is the first study, to the author's knowledge, that implements Flow experience in the form of questionnaires and interviews to gain insight into the perceptions of flow of older adult fallers when undertaking exergames. Previous research has explored differences between exercise groups of individuals with Multiple Sclerosis (MS) (Robinson et al., 2015) and active and inactive younger adults (Barry et al., 2016). This contrasts with the previous literature in different populations where levels of flow had been higher in the exergaming group compared to groups without the use of technology.

7.3.1 The broader reaches of exergaming

Ageing is one of the most important global issues of the 21st century. Exercise interventions can reduce the rate and risk of falls for older adults (Sherrington et al., 2011), but can also have an impact on adjoining areas of an individual's life. Physical activity enjoyment, for example, is predictor and outcome of physical activity participation, which has previously increased exercise intention (Mullen et al., 2011). Participants in both intervention groups reported high levels of physical activity enjoyment in interviews following the intervention and differences between the groups were not statistically significant for the Physical activity enjoyment scale (PACES). Participants were asked in the interviews if they would repeat the programme in which participants often stated that they would because of enjoyment ties, which agrees with the literature that enjoyment is associated with exercise intention (Mullen et al., 2011). Physical activity interventions have also known to have significant reducing effects on depression in older adults. Physical activity has previously shown to be protective for both prevalent depression (adjusted odds ratio (OR) = 0.90, 95% confidence interval (CI): 0.79, 1.01) and incident depression (adjusted OR = 0.83, 95% CI: 0.73, 0.96) over 5 years (Strawbridge et al., 2002). Participants in the pilot intervention reported no depressive symptoms or negative impact on training in the interviews following the intervention and mean Geriatric Depression Scale (GDS) scores at baseline were beneath the cut-off mark for symptoms suggestive of depression (>5 points). Overall depression scores were lower following the intervention with greater improvements seen in the Steady group compared to the Mira group. This suggests that involvement in any form of physical activity programme can depressive symptoms, which is a two-way street, as increases in depressive symptoms can influence a reduction in participation in future exercise programmes, yet increased participation in exercise programmes can reduce depressive symptoms (Barbour and Blumenthal, 2005).

Given the importance of older adults (fallers and non-fallers) as beneficiaries of public health behaviour change interventions, health status measures should be appropriately administered for this section of the population (Walters et al., 2001). The implementation of the SF-36 scale was successful in that all participants completed questionnaires at baseline. The attrition in the Steady and control groups at post assessment were of similar percentages (86.7% and 90%, respectively) to the completion of the other self-report measures. An interesting finding in from observation of the descriptive statistics is that the Mira group mostly improved in physical functioning, energy/fatigue and pain subscales of the SF-36, whereas the Steady intervention group improved more so in the emotional functioning, well-being, energy/ fatigue and social subscales of the SF-36 health scores. This could associate more benefit in the areas of the scale with the mode of intervention delivery (group exercise versus individualised training). Further investigation is warranted in regard to the mode of intervention delivery and its effects on health-related quality of life pertaining to exergames. Cognitive impairment had improved during the intervention period. Steady group participants had a lower mean cognitive impairment (MMSE) score, which could be related to the lack of a cognitive element during the training programme. This is an assumption, yet this could pose as an argument for cognitive elements within fall prevention classes within the community, through use of exergames or alternative means.

7.4 Limitations of the research

This thesis begins by presenting a range of strengths of the research:

This thesis provides two systematic reviews of the exergaming literature pertaining to postural control and fall prevention for older adults. The reviews provide novel information pertaining to outcomes of postural control, although supported with low quality evidence, and outcome measures. The reviews also provide evidence on movement characteristics of exergames with respect to postural control theory, providing important findings which may inform future design of exergaming interventions and exergames.

The current thesis offers novel methods to train postural control pertaining to the implementation of a tailored exergame (Mira™) for use with older adult fallers. This thesis also offers application of an outcome measure to asses postural control with respect to underlying physiological systems and relates to a framework for postural control (Horak, 2006), and offers a novel method to assess physical activity using an instrumented method of assessment which is community mobile. Using the recommended guidelines from the Medical Research Council (MRC) for implementing complex interventions in the community, this thesis provides important preliminary development work in order to implement a future definitive trial, with novel methods of assessment in the community for older adult fallers.

The application of a BWM to objectively support observer rating when administering the Mini-BESTest added a novel aspect to the thesis. However, although all 14 tasks were instrumented and data collected, the time period of the PhD meant that only one task could be presented in the thesis. We chose the task that constitutes the gold standard of functional assessment of dynamic balance and gait, the Timed Up and Go Test (TUG) and the TUG with a dual task, which was implemented successfully and provides insight into using objective measures outside of a laboratory environment to quantify functional assessment and monitor physical activity patterns long term.

This thesis offers a new approach to measuring postural control and rating movements conducted during exergaming interventions with respect to a theoretical framework for postural control, the Systems Framework for Postural Control (SFPC). This is the first study, to the author's knowledge, to implement the Mini-BESTest, instrument the 14 tasks of the scale and utilise a movement rating scale to assess postural control for older adults undertaking exergames.

Despite the contributions to knowledge, a number of limitations must be considered and can direct opportunities for future research in the field of exergaming to train postural control. The lack of participants over the age of 63 years in the focus group study means generalising to an older cohort is not possible from this thesis in regard to technology acceptance and behavioural intention of commercially available exergames. Although not a requirement for feasibility studies, the lack of ability to randomise participants during the pilot intervention meant testing the feasibility of procedures for randomisation for a future RCT in the local community was not possible. This procedure was not possible during the thesis as issues in recruitment meant data collection began at separate times on a group by group basis. During the pilot intervention, neither the investigator nor the participants were blind to the exercise condition. The lead investigator was the sole researcher for this thesis and had to be present for all training sessions, assessments visits and interviews. This potentially opens up the preliminary results to several biases. Although the main aim of the trial was feasibility, testing the feasibility of blinding procedures is required prior to implementation of a full RCT. As per recommended guidelines, the ability to conduct a process evaluation following the feasibility trial was not possible due to time constraints of the thesis. The ability to assess whether behaviours had been maintained longitudinally could not be assessed during the time period of this PhD programme. A future definitive trial could benefit from understanding the longitudinal effects of a tailored exergame on postural control of community-dwelling older adults.

This thesis has introduced important developmental work for implementing a tailored exergame for use with older adult fallers with respect to postural control theory and is underpinned by frameworks and models that direct the development in a systematic manner. The recommendations detailed below provide areas for potential development and future directions for exergaming research and development.

7.4.1 Testing randomisation

The current thesis provided preliminary information during the pilot intervention, pertaining to the feasibility of exergames to improve postural control and lower fall risk in older adult fallers, however, further investigation is warranted in the form of a pilot RCT to test the methods of randomisation and participants' willingness to be randomised. A future RCT will contribute to findings pertaining to efficacy of exergaming to improve postural control for older adult fallers and will be generalizable at the population level and may contribute to the development of exergaming guidelines. As part of the development of a definitive RCT, it would also be beneficial to conduct a rehearsal of an economic evaluation for use in a future definitive trial to identify, quantify and value accurately the additional costs of delivering the intervention and any potential resource implications involved. This could be jointly combined with a process evaluation as per recommended guidelines (MRC).

7.4.2 Exergaming technology adaptations

This thesis has used the latest available technology (Kinect™) in an exergaming intervention with the utilisation of a tailored exergame for use with older adults. However, it is well known that the speed in which technology develops makes a difficult feat for exergaming research to stay ahead of the technology development curve. The announcement of the discontinuation of the Kinect™ sensor by Microsoft Corporation indicates exergaming research must adapt to a new technology utilising depth sensors, Red Green Blue (RGB) cameras and infrared cameras. As the Kinect™ sensor is the tool in which exergames can be delivered, the direction of exergaming research will continue to meander with regards to the type of technology available and adapted from the gaming sector. The use of Smartphone applications to support the implementation of exergames in the community have recently been proposed. Clock Yourself™ is a recent innovation in Smartphone applications that utilises multidirectional stepping actions with cognitive elements to train the necessary stepping movements required in unanticipated (fall prone) situations. Designed by a physiotherapist and games designers, Clock Yourself™ is equipment free and only requires the navigation of equipment that is already with the end user (Figure 7.0).

7.4.3 Postural control assessment during gameplay

The ability of Mira™, or exergames in general, to track movement of the user in order to drive the gameplay provides opportunity to track postural transitions during exercise. This would have great benefit to understanding changes in the range, velocity and variety of movements conducted during exergames and the ability to track a user's movement performance during the games would prove beneficial for physiotherapists and clinicians in general. The Kinect was recently used to assess whole body movement patterns using principle component analysis of variance between 3D positions of ten body segments in the frontal plane and compared it to a Vicon 3D motion capture system (van Diest et al., 2014). After deriving balance based outcome measures from spatiotemporal sway characteristics, the Kinect was able to explain variance in trunk movements as accurately as a Vicon system, yet inaccurately explained hand and foot segment variance as much as 30%. The prospect of affordable and community mobile systems coming close to mimicking the capabilities of expensive laboratory based systems provides opportunity to take exergames a step further by tracking postural transitions using Kinematics analysis during gameplay, which takes movement tracking beyond the counting of repetitions over a period of time.

Figure 7.0 – A mind map of the multidirectional stepping exergame “Clock yourself”

7.4.4 Study population

The current thesis provided valuable information regarding the implementation of a feasibility trial to assess postural control in the community using a novel measure with preliminary results for older adult fallers. However, a limitation was that the results can only be applied to older adult fallers. Future research is therefore needed to explore the feasibility of implementing the pilot intervention on more fall prone populations or populations with more disabling conditions such as higher levels of cognitive impairment or more frequent fallers such as individuals with Parkinson's Disease, Cerebral Palsy, Meniere's Disease to name a few. The use of commercial exergames has proven useful for engaging healthy populations to take part in physical activity, however, future exergames should be designed with the user at the centre of its design of both the game and the apparatus. Previous research has shown the lack of adherence to commercially available exergames or incapability to use such complex games (Barry et al., 2014).

Furthermore, this thesis provides detailed information on the implementation of a tailored exergame for use with older adult fallers, however, a limitation was the implementation of this feasibility trial only applies to older adult fallers and not to populations with more debilitating conditions. Future research is necessary to implement the use of the Mini-BESTest and Mira™ or exergames in general, in a more targeted manner, as Mira™ already is designed to consider sub-clinical populations.

7.5 Overall conclusions

This section documents the conclusions in relation to the prospects of the feasibility of exergaming to improve postural control for older adults living in the community.

The preliminary findings from this thesis suggest that the design of the pilot intervention was feasible in the community for older adult fallers, although several considerations must be addressed prior to implementing a future definitive trial.

7.5.1 Thesis highlights

The research highlights the following outcomes:

- Exergaming interventions, in the form of robustly designed RCTs, require more developmental work supported by frameworks of behaviour change to more accurately generalise the effects on postural control and other health related outcomes.
- Outcomes in conjunction with the SFPC are supported by low quality evidence when assessed using the GRADE system.
- Reactive postural control, verticality and cognitive influences are minimally, or not currently assessed in exergaming interventions.
- Movements elicited in exergaming interventions currently do not train all physiological systems related to postural control, supported by the SFPC.
- Technology acceptance, in particular, performance expectancy, effort expectancy, and social influences can potentially predict older adult's intention to use exergame to train postural control in the future.
- Tailored exergames are preferable to commercially available counterparts for use with older adults and are accepted and enjoyed, yet the inability to train

reactive postural control and sensory integration requires additional elements external to the exergame, yet within the intervention.

- An outcome measure underpinned by postural control theory can be implemented and administered appropriately, supported by objective instrumentation.
- The ability to monitor physical activity objectively can be implemented feasibly in the community to compare older adult fallers' physical activity levels in relation to recommended guidelines.
- Exergames hold promise to impact other health outcomes related to increased levels of physical activity such as health and well-being, fatigue, cognitive impairment, depression, physical activity enjoyment and flow.

7.5.2 Future endeavours

Further investigation is recommended in the following areas:

- Applying the outcomes from the pilot intervention to a full definitive RCT to understand the effects of tailored exergames on community-dwelling older adult fallers
- To conduct a meta-regression on the percentage score of rated movements in exergaming interventions, using the SFPC as a rating scale, in conjunction with effect estimates in meta-analyses
- Conduct a process evaluation of the pilot intervention as per MRC guidelines, which includes an economic evaluation of staff, equipment, room hire and consumables.
- Kinematic analysis of movements conducted during Mira™ gameplay using to track postural transitions and provide live feedback to clinicians.

- The use of Mira™ in more clinical populations such as individuals with Parkinson’s disease when using the tailored exergame.

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9.0 APPENDICES

9.1 Appendix A

Published Manuscript: A systematic review and meta-analysis of outcome measures to assess postural control in older adults who undertake exergaming

Robin Tahmosybayat[a], BSc, Katherine Baker[a], PhD, Alan Godfrey[b], PhD, Nick Caplan[a], PhD, Gill Barry[ab], PhD.

[a] Department of Sport, Exercise and Rehabilitation, Faculty of Health and Life Science, University of Northumbria, Newcastle Upon Tyne, UK.
[b] Institute of Neuroscience, Newcastle University Institute for Ageing, Clinical Ageing Research Unit, Newcastle University, Campus for Ageing & Vitality, Newcastle upon Tyne, UK.

Corresponding Author

Robin Tahmosybayat BSc (Hons)
PhD Researcher
robin.a.tahmosybayat@northumbria.ac.uk

Department of Sport, Exercise and Rehabilitation
Faculty of Health and Life Sciences
Northumberland Building, Room 431
Northumbria University
Newcastle upon Tyne
NE1 8ST

Abstract

Exergaming has shown to be an effective tool to improve postural control (PC) in older community dwelling individuals. Outcome measures (OMs) used are varied and individually could hold limitations to the effectiveness of the intervention. This systematic review and meta-analysis aims to explore the OMs currently used to assess PC in exergaming interventions, for healthy elderly individuals > 60 years. The literature search was conducted across five databases (CINAHL, EMBASE, PubMed, ISI, SPORTdiscus and Science Direct) using a range of search terms and combinations relating to exergaming, balance, exercise, falls and elderly. Quality assessment was conducted using the PEDro Scale and a custom-made quality assessment tool. Eleven trials were included in the meta-analysis with a mean (SD) PEDro score of 5.36 (1.57). Primary and secondary OMs showed small effects in favour of alternative training modes, though insignificant for all primary OMs. Tertiary OMs could not be included in the meta-analysis due to varying output parameters from different instrumentation. Heterogeneity remained high across trials and no studies performed long term follow up of exergaming on PC. Exergaming is a potential alternative for PC training, although still in its infancy. Strong and well-designed RCTs are needed targeting specific populations > 60 years. Variability in instrumented OMs prevent generalising aspects of quantified PC. Improvements in technologies may provide data not currently available from clinical and laboratory based methods with means to measure PC more realistically and specifically to a population's ADLs, though this remains a new area of research.
Key words: Exergaming; Postural Control; Elderly; Outcome Measures; Meta-analysis; Community-dwelling; Balance; Falls

1.0 Introduction

1.1 Background

Falls are associated with ageing and disease, with one third of people aged 65 years and older falling at least once per year [1, 2]. In older individuals, a strong predictor of falls is impaired postural control (PC) among other factors [3, 4]. Postural control is the ability to maintain, achieve, or restore a state of balance during any posture or activity [5]. Correct PC requires accurately timed vestibular, visual, proprioceptive and somatosensory inputs for adaptive strategies for orientation and balance [6]. Participation in balance-based training is low due to the tedious and monotonous nature of the training [7]. These therapies are repetitive which reduce attention span and impair the effectiveness of the exercises, particularly the large volume of practice associated with chronic neurological and musculoskeletal conditions [7].

A more recent method of PC training is exergaming [7, 8]. Exergames are computer games driven by the user's gross physical movements. Due to portability, they facilitate community deployment whereby older individuals have experienced exergaming as a form of PC training [9]. The Nintendo Wii Fit™ had been the most popular exergaming instrument and results have shown beneficial effects on PC [9]. Other exergaming models include X-Box Kinect™, PlayStation Eyetoy™ and Dance Dance Revolution™. The X-Box Kinect™ is revolutionary in its development due to being the first commercial gaming system that does not require a hand held controller or external device, more so it requires the use of infra-red technology to track an individual's movements.

Outcome measures (OMs) used in exergaming interventions, employed for balance evaluation, have been previously categorised as functional assessment (documents balance status and change after intervention), systems assessment (determines the underlying reason for impaired balance control), static posturography (quantify postural sway while a subject remains as still as possible) and dynamic posturography (use of external balance perturbations, changing surface and visual conditions) [10]. The Berg Balance Scale (BBS) [11] and the Tinetti Performance Oriented Mobility Assessment (POMA) [12] quantify functional balance in an ordinal pattern as the participant performs balance and mobility tasks that represent activities of daily living (ADLs). The Functional Reach Test (FRT) [13] uses distance to quantify limits of stability of the centre of mass. The Single Leg Stance (SLS) [14] or the Timed Up and Go (TUG) [15] use the time domain to measure the task being performed via a stop watch. These measures provide information about postural control, likelihood of falling and functional capabilities. Inter-rater reliability has been previously reported excellent for BBS, TUG and FRT as has good intra-rater reliability [16]. Unobtrusive self-report questionnaires such as the Tinetti Falls Efficacy Scale (FES) [17] and the Activities-specific Balance Confidence Scale (ABC) [18] measure perception of balance confidence and fear of falling of an individual in performing ADLs.

Force platforms quantify the centre of pressure (COP) excursion in mediolateral (ML) and anteroposterior (AP) direction during quiet stance in varying conditions [7]. The COP has previously characterised postural control by evaluating the relative sensitivity of COP based measures to changes in postural steadiness [19] and has been correlated with poor balance and risk of falls [20]. Older adults have previously demonstrated larger areas of COP excursion on a force platform with eyes open, eyes closed or with visual feedback. They displayed longer movement times, longer path lengths of the participant's centre-of-gravity (COG) to different points within their limits-of-stability, and shorter distances of functional reach when compared with younger adults [21]. Miniaturised electronic-based wearables with inertial sensors (e.g. accelerometers and gyroscopes) have objectively and reliably measured postural sway during quiet stance [22-24]. Wearables have been introduced in clinics as an alternative to evaluating PC in the hope to eliminate clinician bias, increase sensitivity to mild impairments (ceiling effects) and improve reliability of measures [25, 26]. They have been tested in clinical populations whereby a subset of sensitive, reliable and valid instrumented postural sway characteristics had been formed [27].

It appears necessary to systematically explore OMs used in exergaming interventions in the hope to establish if an influence on intervention effect exists and any individual limitations that OMs may hold.

1.2 Objective

The aim of this systematic review and meta-analysis is to explore the outcome measures currently used to assess PC in exergaming interventions for healthy elderly individuals > 60 years.

2.0 Methods

2.1 Search strategy

This systematic review was reported according to the PRISMA guidelines [28]. The systematic review was beyond the stage of data collection and therefore could not be registered with PROSPERO, however, it did receive an official statement pertaining to its satisfaction of the inclusion criteria. This is available upon request. Electronic databases (CINAHL, EMBASE, PubMed, Web of Science, SPORTdiscus and Science Direct) were searched for publications from January 2000 to April 2016 for interventions performed in clinical and community based settings. The key search terms were merged with Boolean conjunction (OR/AND) and applied on three search levels. Key Search terms used were: (exergam* OR exer-gam* OR videogam* OR video-gam* OR video-based OR Wii OR Nintendo OR X-box OR Kinect OR play-station OR playstation OR virtua* realit* OR dance dance revolution) AND (sport* OR train* OR exercis* OR intervent* OR balanc* OR strength OR coordina* OR motor control OR postur* OR power OR physical* OR activit* OR health* OR fall* risk OR prevent*) AND (old* OR elder* OR senior*). Three levels of screening were carried out: (1) title, (2) abstract, and (3) full-text. The reference lists of the included articles were also searched. Inclusion/exclusion criteria were agreed upon by the two reviewers (RT & GB).

2.2 Selection Criteria (PICOS)

Table 1: Inclusion and exclusion criteria

	Inclusion	Exclusion
Population	Older Individuals between the age of 60 and 85 years old, no neurologic or orthopaedic condition, community dwelling or independently in retirement centres, without cognitive impairment, able to ambulate independently without assistive devices were included.	Individuals who were outside the age range of 60 - 85 years old. Populations with specific neurological (i.e. stroke, Parkinson's disease, and multiple sclerosis), metabolic (i.e. diabetes), or musculoskeletal (i.e. rheumatoid arthritis) deficits that might impair PC were excluded.
Intervention	Intervention group treated with exergaming as balance training only or combined with other forms of training such as strength training were included.	Studies where the intervention group was not treated with exergaming as balance training (i.e. virtual reality treadmill training, biofeedback) was excluded.
Comparison	A comparison group treated with traditional balance training or with no intervention or both were included.	Studies not utilising any comparison groups were excluded.
Outcomes	Outcome measures designed to objectively and subjectively assess PC (functional assessment, laboratory based assessment, self-report assessment).	Balance as a tertiary measure was excluded.
Studies	Randomised controlled trials (RCT), controlled trials (CT), two group pre and post comparison studies, whereby primary outcome measures were used to assess balance or PC either/or before, during and after a bout of exergaming were included.	Studies with fewer than six participants in each intervention group were excluded. Studies in which no inferential statistics were reported were excluded. Studies that did not meet the inclusion criteria (e.g. all (non-human) animal research)

2.3 Data Extraction

Quantitative data were extracted by one reviewer (RT) and checked by another (GB). Specific details about the interventions, populations and study methods were extracted. Primary methods to assess PC were categorised based on traditional standing and functional mobility tests categorised into rating scales, distance based measures and timed tasks. Secondary methods were based on self-report measures of balance and fear of falling (self-report questionnaires). Tertiary methods were categorised as any instrumentation that quantified PC (force platforms, perturbation platforms and accelerometers).

2.4 Quality Assessment

Evidence level of included studies were assessed using the Oxford 2011 Centre for Evidence-Based Medicine Levels of Evidence [29]. Of the five levels of evidence, level 1 is deemed to be the highest quality of evidence (supplementary file 1, A). To eliminate unintended bias while assessing the studies, both reviewers collaborated and eliminated any conflicting opinions. Eligibility and quality of studies was assessed using the Physiotherapy Evidence Database Scale (PEDro) and were independently assessed by both reviewers (supplementary file 1, B). Methodological quality was also assessed using a custom-made tool derived from a previous systematic review (supplementary file 1, C) [30].

2.5 Data analysis

Intervention effects were assessed by grouping studies for meta-analysis by the method of assessing PC (Primary, secondary and tertiary). The difference of the target outcome between the intervention and the control group including the pooled standard deviations, were calculated for different categories of outcome measure. Random effects models (Review Manager (Revman), version 5.3, Copenhagen, Denmark) were used and between-group standardized mean differences (SMD) were calculated based on continuous measurement scale (mean ±SD). Hedge's g was used to quantify effect sizes for SMD to account for small sample sizes (n<20). For trials utilising multiple intervention arms and compared an exergaming group with an alternative balance training group (group fitness, standardised balance training program, Tai Chi etc.) and a control group (no exercise), the alternative balance training control group were compared to the exergaming group. Where a secondary active control group was included in the study, the control group most representative of traditional balance training was compared to the exergaming group. If the heterogeneity test revealed a value of $p < 0.1$ or $I^2 > 25\%$, then heterogeneity was considered likely. Heterogeneity was deemed moderate at <50% and considerable at >50% [31, 32].

3.0 Results

3.1 Search Strategy

The database search yielded 809 publications (Figure 1). After removing all duplicates (346), 463 publications were abstract screened whereby 435 were excluded leaving 28 publications. After searching reference lists of the 28 included publications, an additional 26 were obtained leaving 54. Of the 54 publications, 42 were excluded with reasons to give the final number of included publications for qualitative synthesis in the review (n=12). The publications remaining for qualitative review can be found here (supplementary file 1, D). Of the 12 publications, one was excluded from the meta-analysis where insufficient data were reported. Data was acquired from one author [33] and another failed to respond [34]. Additionally, the Cochrane Central Register of Controlled Trials revealed no further publications for inclusion is this review.

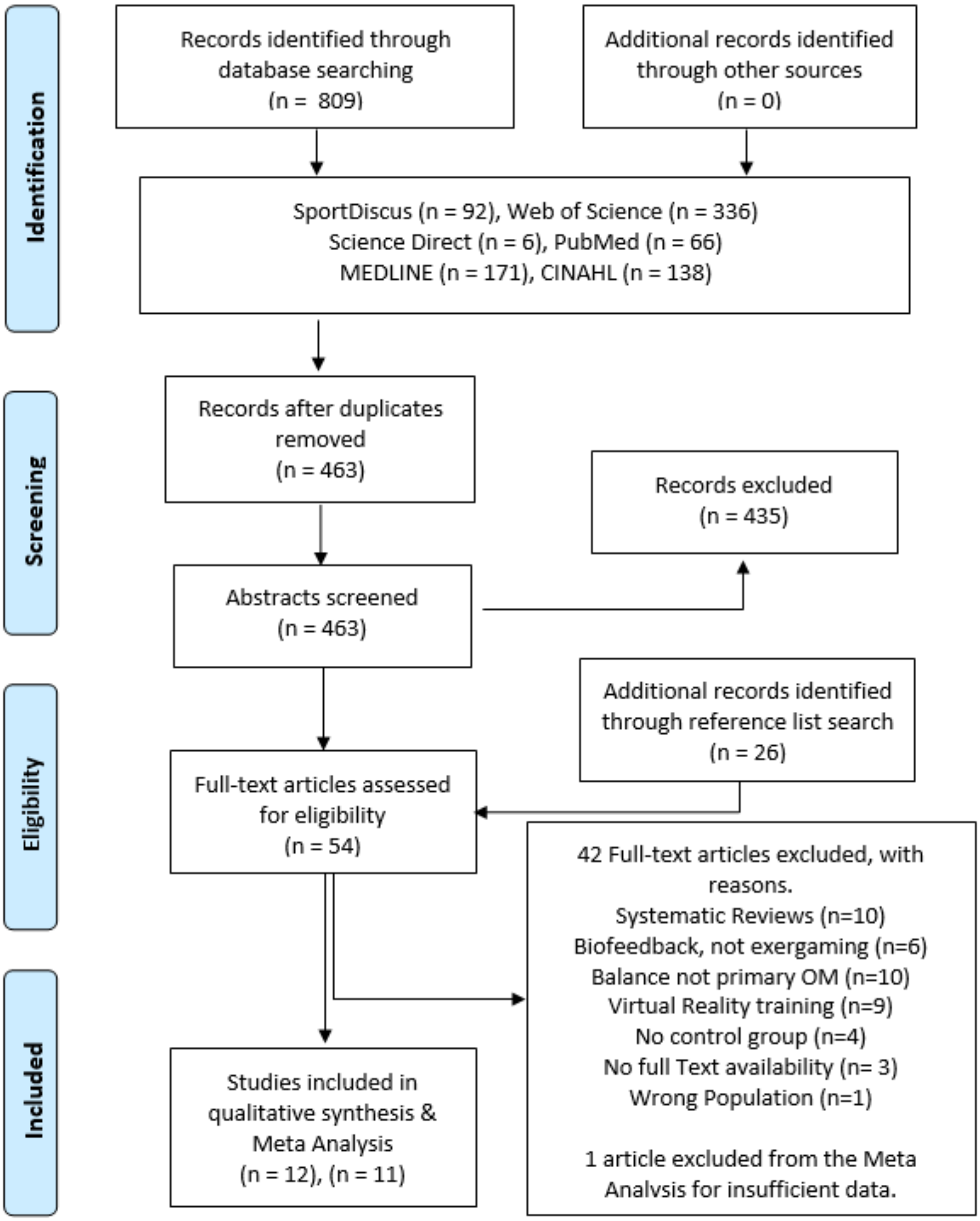

Figure 2. Flow of study screening and selection

3.2 Quality Assessment

Nine of the included publications were considered level 2 evidence (RCT's) and 3 non-RCT's were considered level 3 evidence base (supplementary file 1, E). The mean (SD) methodological quality score of the 12 trials included in the review was 5.17 (1.64). This increased to 5.36 (1.57) for the eleven trials included in the meta-analysis. When excluding the level 3 evidence trials (non-RCT) from the quality assessment the score increased to 5.44 (1.74). A third of the trials reviewed were rated below the mean score which can be attributed to a lack of blinding of the participants, therapists and assessors and a lack of allocation concealment (Table 3). There was a seeming lack of explanation for randomisation across trials with only two studies adequately explaining the method for randomising participants. Six trials failed to describe location and no intervention follow up was conducted for any of the trials (supplementary file 1, F).

Table 2. Overview of the study design, sample characteristics, groups, intervention type and location for included studies

Author and Date	Study Design	Sample: Population; Sample Size (n); age, years (mean ± SD), M/F	Groups	Intervention & Follow up (Y/N)	Location/ Settings
Pluchino et al., 2012	RCT 3 arms (PS)	Community-dwelling older adults, n=40; 72.5 ± 8.4 years, 15/25	IG1 : Standard Balance Exercise ; (n=14), IG2 :Tai Chi (n=14), IG3 : WF (n=12)	60 minutes, 2 x per week, 8 weeks. (N)	Research laboratory/training facility, Wii group unsupervised.
Ray et al., 2012	RCT 3 arms	Community-dwelling older adults, n=87, 75 years (no SD given), 29/58	GF: (n=40), WF + weighted vest: (n=29), CG: (n=18)	GF & WF: 3 x week 45 mins duration, 15 weeks. (N)	Laboratory
Toulotte et al., 2012	RCT 4 arms	Community-dwelling older adults., n=36, 14/22. See adjacent column for mean age (SD) per group	G1: APA, (n=9, 84.2 ± 8.1 years, 3/6). G2: Wii Fit, (n=9, 72.2 ± 8.6 years 4/5). G3: APA + WF, (n=9, 76.4 ± 4.7 years, 3/6). G4: CG (n=9, 71.8 ± 8.0, 4/5).	60 minutes per week x 20 weeks. (N)	Gymnasium at retirement centre
Merriman et al., 2015	RCT 2 arms	Community-dwelling n=59 & Retired Persons n=17, subgroups: healthy n=42, fall prone n=34, 16/60. See adjacent column for mean age (SD) per group	IG: Balance Training (n=38, 17 his of falls, 74.06 (6.66) years, 21 healthy, 74.90 (8.97) years, 1/37). CG: (n=38, 17 his of falls 73.41 (7.00) years, 21 healthy 74.33 (11.09) years, 15/23)	IG: 5 weeks, 2 x 30 min BT/week CG: diary of light, med, heavy Physical Activity. (N)	Sheltered accommodation / community centre / testing laboratory
Sato et al., 2015	RCT 2 arms	Community-dwelling older adults, n=54, 69.25 ± 5.4 years, 11/43	IG: (n=29) CG: (n=28)	65.34 (9.63) days, 40 mins - 1 hour per session, 2-3 times per week, total 24 times. (N)	N/A
Whyatt et al., 2015	RCT 2 arms	Sheltered accommodation and local activity groups, n=84, 25/57. See adjacent column for mean age (SD) per group	IG: Balance Game Training, n=40, 77.18– 6.59 years, 5/35. CG: n=42, 76.62– 7.28 years 20/22. Subgroups. High Risk Falls: IG: (n=15, 77.73 – 8.01 years, 2/13). CG: (n=12, 79.00 – 7.03 years, 6/6). Low Risk Falls: IG: (n=25, 76.83– 5.64 years 3/22). CG: (n=30, 75.67 – 7.28 years, 14/16).	IG: 30 minutes per session, 10 x sessions; over 5 weeks. CG: 5 weeks of recording levels of physical activity. (N)	N/A
Lai et al., 2013	RCT 2 arms	Community-living persons n=30, 72.1 [4.8] years, 13/17	Group A: (n=15, 70.6 (3.5) years 7/8). Group B:(n=15, 74.8 (4.7) years, 6/9). Both Groups performed an intervention phase and a control phase.	12 weeks' trial. IG: 30 min, 3 times/ week x 6 weeks then 6 weeks no exercise. CG: no exercise x 6 weeks then IG 6weeks. (N)	N/A
Singh et al., 2013	RCT 2 arms	Community-dwelling older women, n=38, 36 completed intervention.	IG: balance-focused virtual-reality games 61.12 (3.72) years, CG: therapeutic balance exercises: 64.00 (5.88) years,	30 minutes, 2 x / week for 6 weeks. (N)	N/A
Chow and Mann, 2015	RCPS 2 arms	Community-dwelling, n=20, 69 (range 65 - 78), 7/13	IG: Daily Cyber Golfing n=10, 70.4 (5.4) years, 3/7 CG: regular table games n=10, 68.0 (3.0) years, 4/6.	Daily, 30-45 minutes for 2 weeks. (N)	N/A
Nicholson et al., 2015	Non-RCT	Local retirement villages and educational settings, n=41, 74.5 (5.4) years, 14/27	IG: Wii group (n = 19, 75.11 (5.85) years, 7/12, 2 fallers). CG:(n = 22, 73.91 (5.12 years, 7/15, 3 fallers)	IG: 3 × 30 min Wii Fit sessions per week for six weeks. CG: usual everyday activities and exercise routines. (N)	Unsupervised, in pairs in community hall of a retirement village
Park et al., 2015	Non-RCT	Community Dwelling Individuals, n=30	VRG: (n=15, 66.5±8.1 years, 9/3) and a BEG: (n=15, 65.2±7.9 years, 10/2)	30 min 3 times a week for 8 weeks. (N)	N/A
Tange et al., 2012	Non-RCT (PS)	Elderly individuals, n=39,	WSG: n=20 77 (68-82) years, WF: n=19, 84 (80-89) years	2 x / week during 6 weeks in one-hour sessions. (N)	N/A

RCT = randomised control trial; (PS) = Pilot Study; SD = Standard Deviation; M/F = Male/ Female; (n) = number; (Y/N) = Yes/No; G1 = Group 1; G2 = Group 2; G3 = Group 3; G4 = Group 4; APA = Adapted Physical Activities; WF = Wii Fit; CG = Control Group; IG = Intervention Group; GF = Group Fitness; VRG = virtual reality group; BEG = Ball Exercise Group; WSG = Wii Sports Group; N/A = Not Applicable; mins = minutes.

Table 3. Outcomes from PEDro scale quality assessment

Author and Date	Eligibility Criteria	Random Allocation	Concealed allocation	Baseline Comparable	Blind Subject	Blind Therapist	Blind Assessor	Adequate Follow up	Intention to treat	Between group comparison	Point Estimates and Variability	Total
RCT												
Pluchino et al., 2012 *	Y	Y	Y	Y	N	N	N	N	N	Y	Y	5
Ray et al., 2012 *	Y	Y	N	N	N	N	N	N	N	Y	Y	3
Toulotte et al., 2012 *	Y	Y	Y	Y	N	N	N	Y	N	N	Y	5
Merriman et al., 2015 *	N	N	N	N	N	N	N	N	Y	Y	Y	3
Sato et al., 2015 *	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	8
Whyatt et al., 2015 *	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5
Lai et al., 2013 *	Y	Y	N	Y	N	N	Y	Y	Y	Y	Y	7
Singh et al., 2013 *	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	7
Chow and Mann., 2015 *	N	Y	N	Y	N	N	N	Y	Y	Y	Y	6
Non-RCT												
Nicholson et al., 2015 *	N	N	N	Y	N	N	N	Y	Y	Y	Y	5
Park et al., 2015 *	Y	N	N	Y	N	N	N	N	Y	Y	Y	4
Tange et al., 2012	Y	N	N	N	N	N	N	Y	N	Y	Y	3
Total	9	8	4	9	1	1	3	8	5	10	12	

RCT = Randomised Control Trial; Non-RCT = Non Randomised Control Trial; Y = Yes; N = No; * = Included in Meta-Analysis.

3.3 Data Extraction

Intervention characteristics are available in Table 2. Intervention duration ranged from 5 to 20 weeks, individual sessions ranged from 30 to 60 minutes and session frequency ranged from 1 to 3 times per week. The majority of interventions were conducted in a research facility or a dedicated testing room in a community centre. None of the interventions took place in the home environment and two trials performed exergaming unsupervised [35, 36] (Table 3). Trials were conducted in the USA [35-37], the UK [38, 39], The Netherlands [34], France [40], Malaysia [41], Hong Kong [33], Japan [42], Taiwan [43] and South Korea [44].

3.4 Intervention Effect

3.4.1 Primary and Secondary OMs

Of the 11 trials included in the meta-analysis, six reported PC outcomes from rating scales [35, 38-40, 42, 43], three reported stand and reach tasks, one reported a sit and reach task [33, 35-37] and seven trials included timed tasks consisting of standing balance and mobility assessment [33, 35-37, 41, 43, 44]. Data for included studies can be viewed in supplementary file 1, G. Five trials used self-report methods to quantify balance confidence and fear of falling [35, 36, 38, 39, 43]. Four trials used various versions of the falls efficacy scale [35, 36, 38, 43]. Two trials administered the ABC scale [38, 39], one trial administered fall risk for older individuals living in the community [35] and one trial administered a questionnaire to measure fear of falling [38].

Exergaming had less of an effect on PC than alternative balance training modes when measured using rating scales (SMD: -0.27, 95% CI = -0.23 to 0.78; I^2 = 80%) (Figure 2) and distance-based reaching tasks (SMD: -0.28, 95% CI -0.70 to 0.15, I^2 = 57%) (Figure 3) but no effect was seen in favour of either intervention method through timed tasks (SMD: -0.03, 95% CI -0.30 to 0.24; I^2 = 50%) (Figure 4). Exergaming had less of an effect on balance confidence and fear of falling than active controls when measured using questionnaires (SMD: -0.23, 95% CI 0.03 to 0.44; I^2 = 0%).

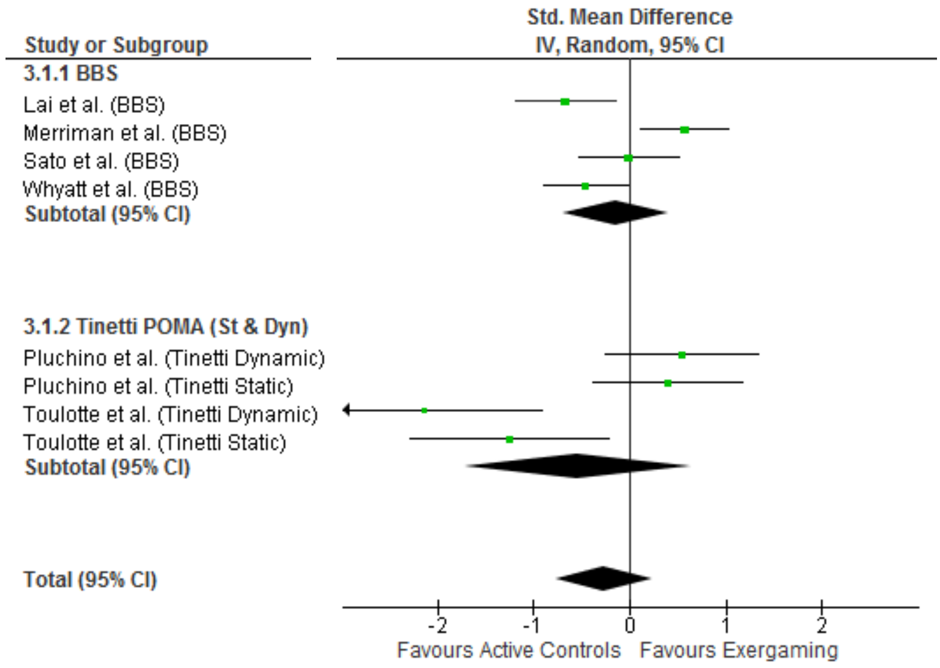

Figure 3. Outcome measures using rating scales for PC assessment in Exergaming vs. active controls. BBS = Berg balance scale; POMA = Performance Oriented Mobility Assessment; Std. = standardised; IV = inverse variance; CI = confidence interval.

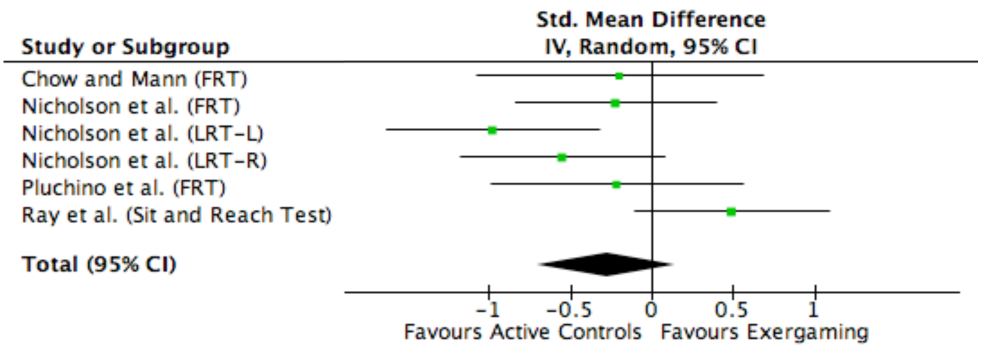

Figure 3. Outcome measures using reaching tasks for Exergaming vs. active controls. FRT = Functional Reach Test; LRT – L = Lateral Reach Test Left; LRT-R = Lateral Reach Test Right; Std. = standardised; IV = inverse variance; CI = confidence interval.

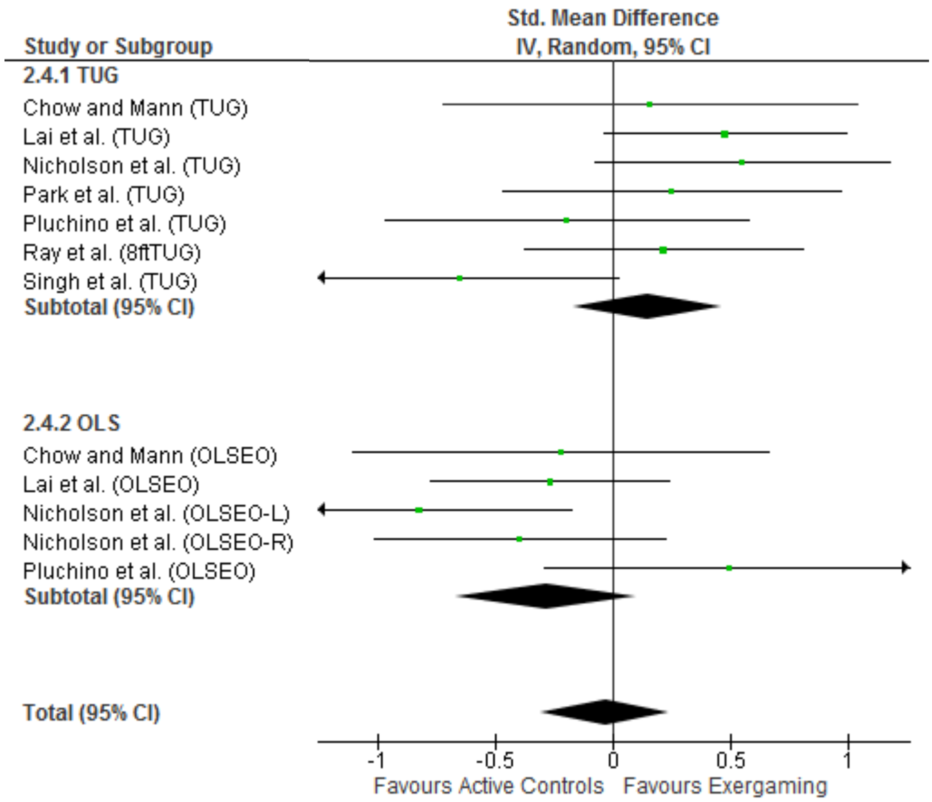

Figure 4. Outcome measures using timed tasks for exergaming vs. active controls. TUG = Timed Up and Go; OLSEO = One Leg Stance Eyes Open; Std. = standardised; IV = inverse variance; CI = confidence interval.

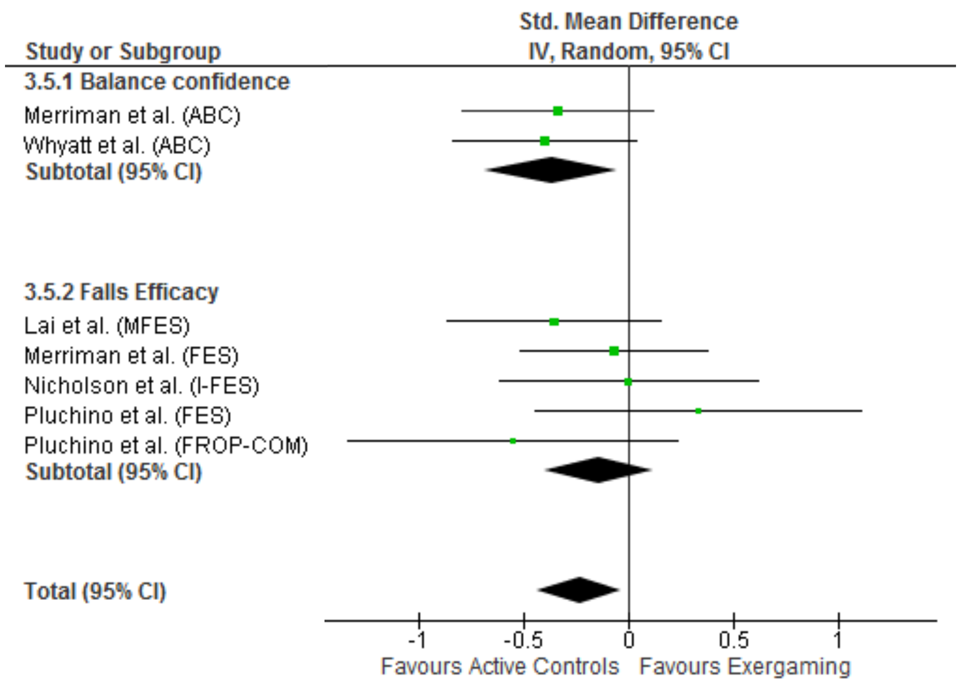

Figure 5. Self-Report Measures of balance confidence and fear of falling for exergaming vs. active controls. FES = Falls Efficacy Scale; ABC = Activities-specific Balance Confidence Scale; FROP-COM = Falls Risk for Older People living in the Community; I = Iconographical and M = Modified; Std. = standardised; IV = inverse variance; CI = confidence interval.

After excluding non-RCT's to observe for any differences in the direction of the effect, the effect made a positive transition towards exergaming for distance-based reaching tasks (SMD: 0.10, 95% CI -0.39 to 0.59, I^2 = 26%) and marginally for timed tasks (SMD: 0.01, 95% CI -0.28 to 0.30, I^2 = 34%), though remained statistically insignificant. A noticeable reduction in heterogeneity across studies was observed for sub-categories of primary OM (supplementary file 1, H). Findings from primary and secondary OMs with insufficient data to pool into meta-analysis can be viewed in supplementary file 1, I.

3.4.2 Tertiary OMs

The instrumentation used to quantify PC had many variations of measurement output which meant inclusion in the meta-analysis was not feasible. Individual results pertaining to intervention effect can be found in supplementary file 1, J.

Table 4. Overview of primary, secondary and tertiary outcome measures used to assess balance

Author and Date	Systems and apparatus	Primary OMs	Secondary OMs	Tertiary OMs	Details
Pluchino et al., 2012	AccuSway Force Platform, Proprio 5000 Dynamic Posturography platform	One-Leg Stance (s), Functional Reach Test (cm), Timed Up & Go Test (s), Tinetti Performance Oriented Mobility Assessment	Falls Efficacy Scale (FES), Falls Risk for Older People–Community Setting (FROP-COM).	The Postural Sway Test (COP + Time to boundary), Dynamic Posturography Test (perturbation platform)	Postural Sway Test Parameters: COP characteristics in AP and ML direction
Ray et al., 2012	NeuroCom SOT	8ft Timed Up and Go Test (s), Chair stand x 15-25 reps weighted, 6-minute walk test, Sit and Reach Test.	N/A	Sensory Organisation Test: 6 conditions, 3 trials/ condition. 18 trials total. 20 s/ trial.	Composite Equilibrium Score of weighted value of 6 conditions: Strategy Analysis score: Scores between 0 and 100 represent a combination of the two strategies; ankle and hip.
Toulotte et al., 2012	Nintendo Wii Fit + WBB	Unipedal Test Eyes Open, Eyes Closed, Tinetti Balance Assessment tool.	N/A	Wii Fit Test - Position of Centre Of Gravity (COG)	The videogame console gives two percentages (right and left) for the position of the centre of gravity. We calculated the percentage difference between right and left and concluded as to the overall position of the centre of gravity.
Merriman et al., 2015	Wii Balance Board (embedded with safety frame surrounding)+ Custom Designed Game	Berg Balance Scale	Balance Confidence (ABC) Scale, Fear of Falling (FOF) Falls Efficacy Scale (FES)	Static and Dynamic Balance Test.	Static: No. of secs within target area (max 10) converted to a percentage. 3 trials per target zone and average score across trials was collected. Dynamic: No of time to reach targets at fixed locations in 60s.
Sato et al., 2015	N/A	Berg Balance Scale, Functional Reach Test (cm), Chair Stand-30s	N/A	N/A	N/A
Whyatt et al., 2015	Nintendo Wii Fit, Wii Balance Board, Zimmer frame for safety, The NeuroCom Balance Master	Berg Balance Scale	ABC Scale	Custom made Static Balance Test (COP Displacement), Dynamic Balance Test - Limits of stability (COP)	Static: percentage of time spent in the target area. Dynamic: No. of targets hit COP displacement. Scores represent levels of COP spatial accuracy and data for all balance tests were converted to percentage change between Session 1 and Session 2.
Lai et al., 2013	The Catsys 2000 system measures postural sway, Xavix Measured Step System (XMSS)	Berg Balance Scale, Timed Up and Go Test (s), Unipedal Stance Test, XMSS stepping test	Modified Falls Efficacy Scale (MFES)	Stepping Test, Sway Area (SA), postural sway (Sway Velocity (SV) of COP in bipedal stance with eyes open and closed)	Sway Area (SA) and Sway Velocity (SV) COP in a bipedal stance with eyes open and closed. Postural sway was measured for 75 s (standard test procedure: 10 s start-up period, 60 s recording period, and 5 s run-out period), while standing directly on the platform
Singh et al., 2013	Probalance System	Timed up and Go Test (s), Ten Step Test		Postural Sway	Anterior –posterior and medial – lateral sway scores were converted to an overall performance index (OPI) by the Probalance software program. Lower OPI scores reflect better ability to regulate postural sway.

Chow and Mann, 2015	N/A	Timed up and go test (s), Single leg stance test, Functional Reach test (cm).	N/A	N/A
Nicholson et al., 2015	N/A	Timed Up and Go Test (s) Functional reach (cm) Lateral reach left (cm) Lateral reach right (cm) Single Leg Stance left (s) Single Leg Stance right (s) 30-s chair stand, Gait speed (m/s)	N/A	N/A
Park et al., 2015	BioRescue	Timed Up and Go Test (s)	Static Balance	30 sec sway length (mm) & average sway speed (mm^2) EO (COP) + biofeedback
Tange et al., 2012	N/A	Berg Balance Scale at 0, 3, and 6 weeks	N/A	N/A

OMs = Outcome measures; N/A = Not Applicable; COP = Centre of Pressure; SOT = Sensory Organisation Test; (s) = seconds; (cm) = centimetres; (m/s) = metres per second; mm2 = millimetres squared; EO = Eyes Open

4.0 Discussion

This systematic review and meta-analysis aimed to explore OMs used to assess PC in exergaming interventions in individuals aged 60 years or more. The evidence from the meta-analyses suggest that, overall, the use of primary and secondary OMs do not impact the outcome of the intervention although after dividing the meta-analyses by individual measure type, some measures favoured exergaming more so than others and heterogeneity was moderate to high for primary OMs. After removing the non-randomised studies from the meta-analyses, the overall effect swayed toward exergaming.

4.1 Limitations with the measures

The primary measures used in this systematic review consist of clinical balance assessments which were originally created to identify balance problems or the underlying cause of a problem to predict risk of falls and determine effectiveness of intervention [10]. Healthy community dwelling older adults tend to have higher functioning capabilities and the 8 points of clinically significant change [45] required in the BBS questions the validity of this assessment for already high functioning individuals and has shown ceiling effects in this regard [46]. The gait section of the Tinetti POMA is seldom used and has also shown ceiling effects [45]. The FRT, despite its purpose, has not been well correlated with centre of mass displacement due to availability of compensatory strategies to reach not accounted for in the test [47]. The TUG also suffers the inability to detect early onset of impairment and the inability to understand if it is the gait or balance component of the scale that is affected may limit this form of measure. The use of rating scales, distance-based measures and timed tasks is practical and inexpensive for PC assessment however, the ceiling effects observed in this population hinder the ability to predict any future concerns of healthy individuals, which is valuable information in order to understand changes in PC. The use of questionnaires to evaluate self-perceived balance confidence and fear of falling are useful as they are nonintrusive and support the targeted direction of an intervention [10]. The ABC scale was developed on elderly outpatients and the confidence they perceived was based on a perceived need for a walking aid and personal assistance to ambulate outdoors [18]. Balance evaluation measures have been previously rated in terms of the ability to measure different aspects of PC and only one measure assessed all 6 aspects of postural control [48]. Adapted measures could discriminate higher functional balance ability in this specific population, which could result in a greater understanding of the effect of the intervention on PC.The needs of higher functioning older adults are less dependent and more focused on higher levels of activities of daily living [18].

The range of equipment and output parameters relating to the COP characteristics of PC requires consistency in order for instrumented outcome measures to be generalizable in the future. For example, comparing COP parameters using a force platform in Pluchino et al.'s [35] trial with the percentage change of the COG measured on a Wii Balance Board in a trial by Toulotte et al. [40]. Several studies did report that participants tended to enjoy exergaming and increased motivation was observed but not measured in several trials. This concurs with several previous systematic reviews [49-51]. A limitation to force plate PC assessment is the inability to measure stepping action of dynamic balance, or indeed the dynamic balance accounted for during gait [52]. Individuals perform reactive and proactive PC adjustments on a force platform [20], but with the individual rooted to the platform, whether it is embedded or raised, not all components of the PC system are challenged as the base of support remains in a static state. Recent research has shown the importance of stepping action for prevention of falls and improving PC [53]. Postural control demands may be influenced by the complexity of the task and the environment in which the task is performed [54]. The use of a body worn accelerometer (BWA) to track PC and gait in any environment has previously been demonstrated as part of the development of an instrumented physical capability assessment (ICAP) [26], yet was not used to quantify PC in any of the trials in this review. The ability of BWA to track PC over a period of time with standardised protocols [25] could enable accurate assessment of PC in community environments for both healthy and fall prone individuals, with varying complexity of task and environmental demands. The potential for BWAs to be able to track higher functioning older individuals may eliminate the psychometric limitations seen in more traditional methods.

4.2 Overall effect

The meta-analyses did show that exergaming interventions are less effective when compared to alternative balance training modes. After adjusting the meta-analyses to include only RCT's there was a shift in effect which could be attributed to the removal of non-RCTs. This is an assumption and must be considered lightly. None of the trials included in the current review performed follow-up measurements leaving a gap in the knowledge of long-term effects of exergaming on PC. Previous systematic reviews have also reported similar findings [9, 55] although reported on *p* values alone. The use of meta-analyses to report effect sizes are arguably more appropriate for intervention evaluation [50].

4.3 Strengths and Limitations

This systematic review was conducted in line with the PRISMA statement. The effects of the current meta-analysis must be taken with caution due to the small number of trials included in the review. The high heterogeneity and a lack of intention-to-treat analysis may not give a comprehensive picture of the effects of exergaming on PC. Furthermore, this review reported on healthy community dwelling individuals only and not those with pathological conditions and at higher risks of falls. The non-RCT's used in the meta-analyses sway potential biases and although we attempted to account for the differences, results should be interpreted carefully, particularly concerning selection bias and reporting bias.

5.0 Conclusion

Exergaming is still in its infancy and heterogeneity in intervention design may affect the overall intervention effect. High quality RCTs with long periods of follow up are needed in order to inform recommendations for exergaming interventions focusing on improving PC. OMs used to assess PC in this population hold psychometric limitations and balance measures do not assess all aspect of PC. OMs that can differentiate balance problems within this population may help direct exergaming interventions. Improvements in technologies may provide further insight with means to measure PC more specifically to a population's ADLs.

Conflict of Interest statement

The authors declare that there are no conflicts of interests.

Additional File 1. Supplementary data and Figures

Supplementary data to this article can be found in additional file 1.

Acknowledgements

This research is funded as part of a PhD programme within the Faculty of Health and Life Sciences at Northumbria University, Newcastle Upon Tyne, UK.

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9.2 Appendix B

Game environments, instruction, movements, scoring, reward, progression for the 18 publications included in this review.

Nintendo Wii Fit: The Nintendo Wii consists of a console, a nun chuck and a balance board. There are 9 balance games to choose from on screen. Soccer heading, Table Tilt, Penguin Slide, Ski Slalom, Ski Jump, Snowboard Slalom, Balance Bubble, Lotus Focus, Tightrope walk. There is also a clock that counts calories of the participants and this is tracked through the Mii character.

Figure 4.

Review publications using some/ all of these games: Pluchino et al. 2012, Ray et al. 2012, Toulotte et al. 2012, Singh et al. 2013, Nicholson et al. 2015, Park et al. 2015, Tange et al. 2012, Monteiro-Junior et al. 2017, Padala et al. 2017 and Maixnerova et al. 2017.

Soccer Heading – The Mii character is located on the halfway line of a football pitch. The observed environment includes: a semi-transparent version of the Mii character, a football goal, a referee, other football players waiting to take a turn at crossing the ball and three cones. The background behind the pitch is a tall turquoise fence, a light blue sky with some white clouds and some trees.

Figure 5

There is some onscreen instruction prior to the start of the game that indicates the type of movement in order to play the game. There is no instruction of what not to do.

Figure 6

Figure 7

Onscreen top left indicates the number of balls being crossed in a deductive manner starting at 120 (advanced playing level) and top right onscreen indicates the total number of points earned.

Figure 8

The points per ball are shown as below and vary with the number of obstacles (panda heads, football boots) simultaneously approaching with the football with a maximum of 10 points per ball.

Figure 9

Depending on accomplishments (number of balls headed, number of balls missed, number of obstacles headed instead), onscreen reward is given in the form of feedback. Below is an example of advance level perfect score (headed all balls, did not head any obstacles) rewarded with the word 'Perfect!' and onscreen fireworks.

Figure 10

This is then reiterated with a view of the Mii character celebrating the score and receiving the reward of champion (4 golden stars) followed by the other players forming a circle of celebration for the Mii character and showing the Mii character ranking in a table and calories burned.

Figure 11

Figure 12

Figure 13

Figure 14

Ski Jump - The Mii character is located at the top of jump slope sat on the starting bar looing down the ski slope. The observed environment includes the Mii character, a ski slope and landing arena with seating. The background outside of the arena at the bottom of the slope is snow covered and some trees.

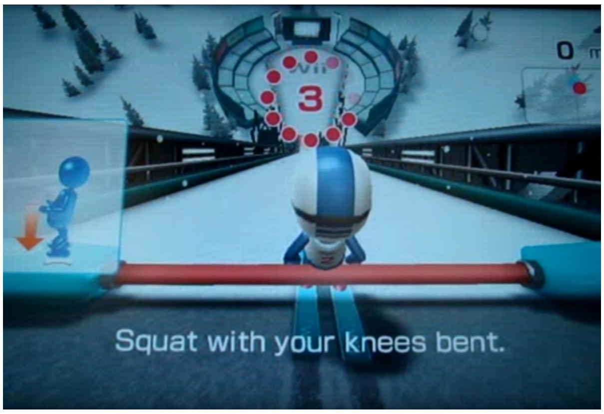


Figure 15

There is some onscreen instruction prior to the start of the jump that indicates the type of movement required in order to play the game. There is no instruction of what not to do. As the Mii character jumps the distance is shown in the top right of the screen and more onscreen instruction is given for the airborne part of the jump.

Figure 16

Upon landing, the distance is given on screen and the Mii character shows an emotional reaction to the jump, whether it is a good or bad jump.

Figure 17

Figure 18

The Mii character then jumps a second time and repeats the exact same process. The final score is presented at the end for both jumps and the outcome reward for the Mii character is given in golden stars and a title from unbalanced, amateur, and professional to champion. The user can then see the rankings table.

Figure 19

Figure 20

Ski Slalom - The Mii character is located at the top of slope behind the starting bar. The observed environment includes the Mii character, a ski slope and finishing arena with seating. The background outside of the arena at the bottom of the slope is snow covered with some trees, buildings and some images show blue sky.

Figure 21

Figure 22

There is some onscreen instruction prior to the start that indicates the type of movement required in order to play the game. There is no instruction of what not to do.

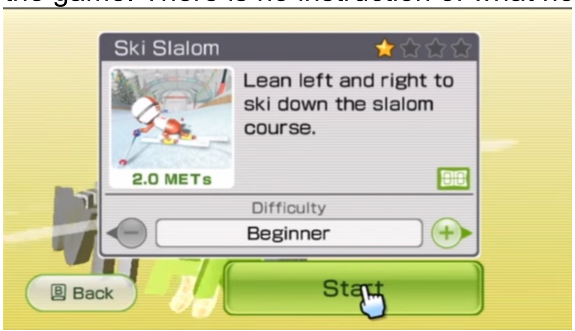


Figure 23

Figure 24

As the race begins, at the top right shows the speed of the Mii character and the location of the centre of gravity, bottom left onscreen shows how many flags are missed and bottom right shows the overall time taken

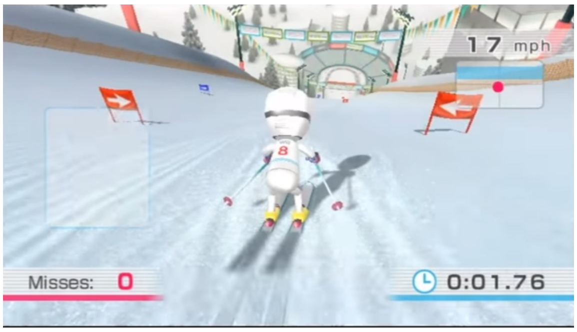


Figure 25

During the race each time the Mii passes through a gate a recognising star swirls around the Mii to show the gate has been passed through correctly.

Figure 26

Upon reaching the finish line, the Mii character shows an emotional reaction to the race, whether it is a good or bad race. A banner comes across the screen stating “goal!”.

Figure 27

This is followed by a reaction to the time taken and the number of gates passed through/ overall score by the Mii character and shows the table ranking. Here it’s clear to see the Mii is not happy with the result.

Figure 28

Figure 29

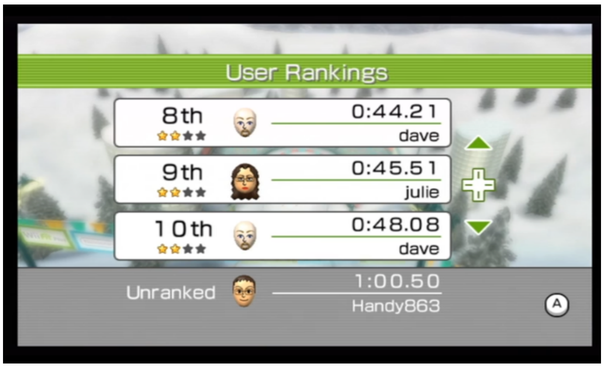


Figure 30

Table Tilt - The individual Mii character is not shown on this game but the face of the Mii character is on the ball. The observed environment includes the ball with the Mii character's face on it, a floating floor that changes shape and number of holes with each level. The background behind the floating floor consists of shapes of equal size that make a wall and change colour.

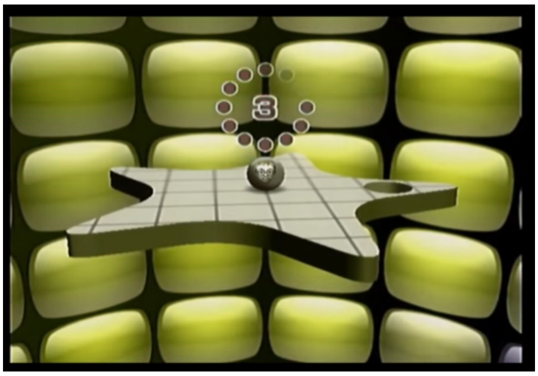


Figure 31

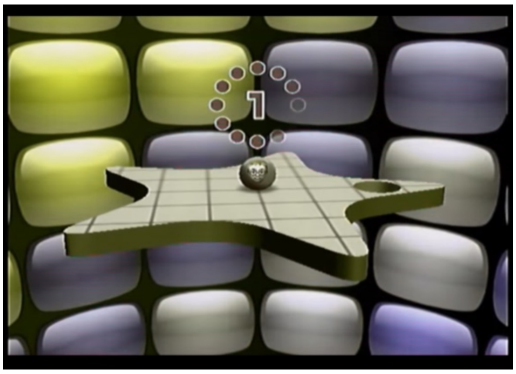


Figure 32

There is some onscreen instruction as the level starts that indicates the type of movement required in order to play the game. There is no instruction of what not to do. Each time

Figure 33

As the balls pass through the holes, the hole glows as a recognition to success and the time (seconds) onscreen at the top increases with each successful level completed.

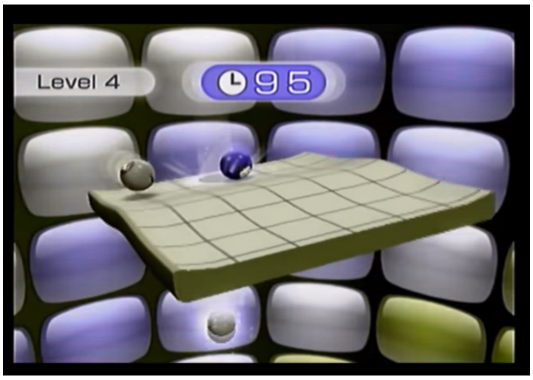


Figure 34

If the balls pass over the edge of the floating floor

Figure 35

They reappear by dropping down from the top of the screen

Figure 36

If time runs out, then the game stops with a finished banner across the screen. The balls remain in their place and the Mii character is rated on what has been achieved.

Figure 37

If the Mii character finishes, they react emotionally to their performance. In this case a good win.

Figure 38

The score is presented and added up as the time left over and the number of levels cleared multiplied by 10. The Mii character is given number of gold stars and rated based on the performance. In this case a champion with 4 stars. The user rankings table is then presented.

Figure 39

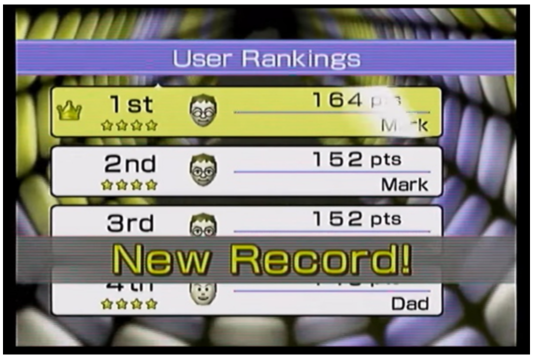


Figure 40

Balance Bubble – The view point of the Mii character is from a birds eye perspective. The Mii character is inside of a multi-coloured bubble floating on a river. At the sides of the screen are some trees and river beds set as simplistic art features.

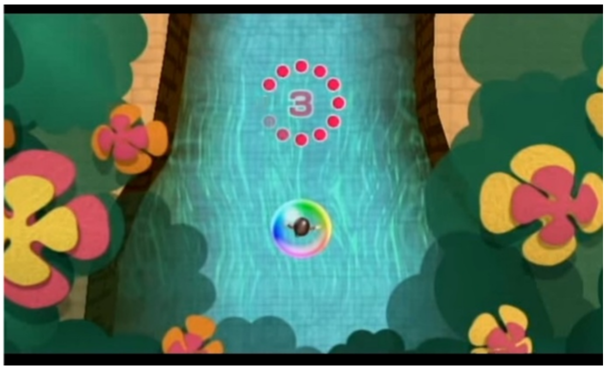


Figure 41

Onscreen instruction as the level starts and the time count down from 1minute 30 second. This is the amount of time that the Mii has to get down the river.

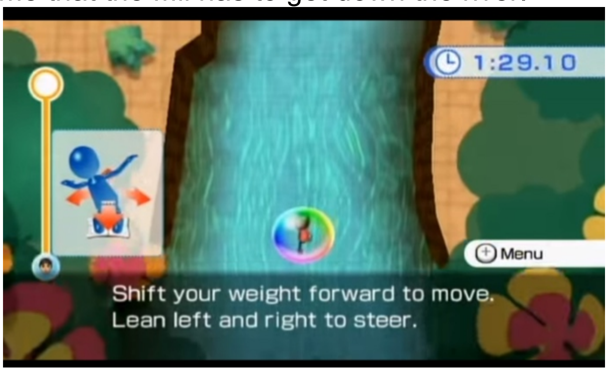


Figure 42

The Mii character has to avoid obstacles such as Bees that can pop the bubble, water ripples that make it harder for the bubble to pass down the river and the sides of the river bank.

Figure 43

Figure 44

Figure 45

In some cases, the Mii character enters a dark part of the river where visibility is reduced.

Figure 46

As the Mii character passes through the rainbow at the end they react emotionally to their performance.

Figure 47

The score is presented as the amount of time taken to pass down the river. In this case the Mii was crowned a professional.

Figure 48

Figure 49

Tight Rope Walk – The Mii character is located on top of a building and is fully visible from the rear. The observed environment includes the Mii character, a different coloured building at the other end of the rope with some other Mii characters in the windows and a very large "finish" sign. There is a green sky with clouds and some birds occasionally flying past the rope as a virtual distraction.

Figure 50

Again, there is instruction as the game has started directing the Mii character. There is a clock counting down at the top right corner onscreen.

Figure 51

Figure 52

Figure 53

Figure 54

Figure 55

If the Mii is close to falling, their arms frantically move round in circles and sweat droplets spray out. There is evidently a big drop if a mistake was to occur.

Figure 56

Figure 57

The Mii character has to jump over a moving bear trap type obstacle and onscreen instruction is given in the build up to the jump.

Figure 58

When the jump is executed correctly, the Mii character jumps highly over the obstacle. However, the individual participant is told not to jump on the balance board.

Figure 59

As the Mii character gets closer to the end the other Mii characters in the windows begin to cheer them on and start waving as reward.

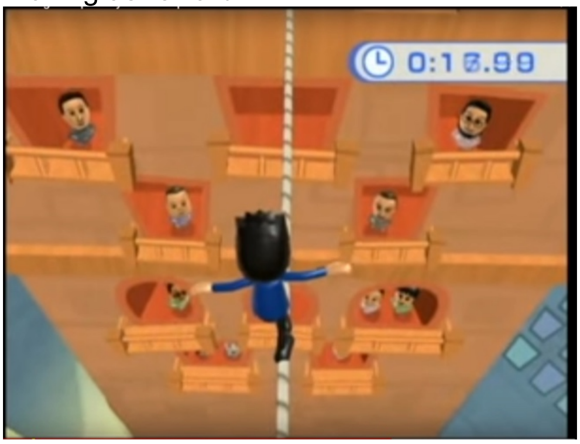


Figure 60

During the last ten seconds the countdown clock turns red to let the user know that time has nearly ran out adding pressure to the situation of finishing the walk.

Figure 61

The Mii character celebrates finishing on time and is rated on time taken to complete the walk. As this user just finished with 0:00:04 seconds to go, they were rated amateur and table rankings were shown.

Figure 62

As no other user had completed the walk before this user came first but with a time that should be easily improved in the future. Hence professional or champion badges were not given in this instance.

Figure 63

Snowboard Slalom - The Mii character is located at the top of slope behind the starting bar. The observed environment includes the Mii character, a ski slope and finishing arena with seating. The background outside of the arena at the bottom of the slope is snow covered with some trees, buildings and some images show purple sky. There is some on-screen instruction and demonstration to show how to do the correct movements. In this case, the individual got a high score and was named a Champion as all of the gates down the slope were passed through in a certain time.

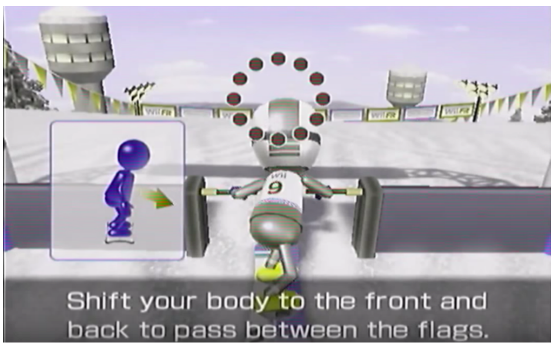


Figure 64

Figure 65

The Mii character has to guide through the gates which become more challenging with more speed and a higher level of play. This mainly consists of antero-posterior sway movements by the participants.

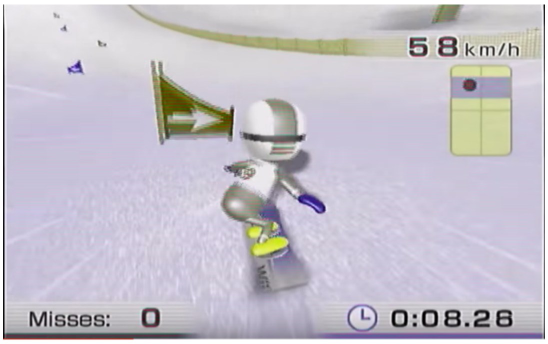


Figure 66

When the participant crosses the finish line there is either happiness or disappointment as to how they performed. In this case the participant had performed very well by passing through all the gates.

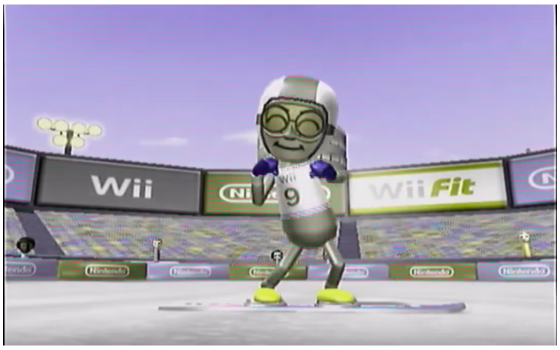


Figure 67

Figure 68

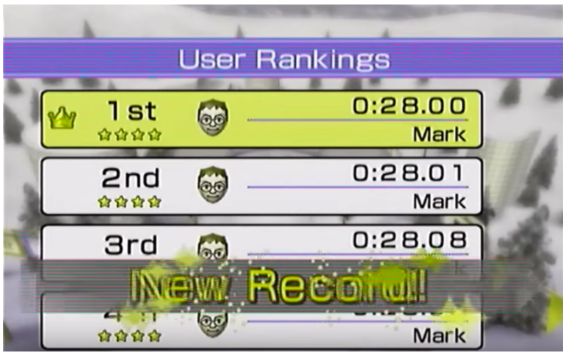


Figure 69

Wii Fit Yoga – There are 18 different yoga positions to train with. This is led by an on-screen instructor that appears to be in an on-screen yoga/ dance type room with a big mirror on the back wall reflecting all movements from a different angle. The emphasis of each game is slightly different but the general consensus is to control the posture during different movements whilst breathing correctly. Here is an example of the deep breathing position.

Figure 70

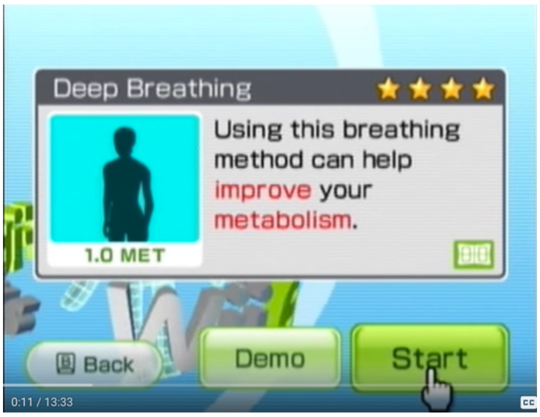


Figure 71

Figure 72

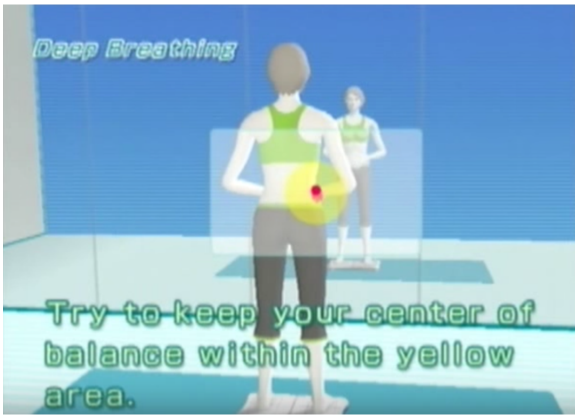


Figure 73

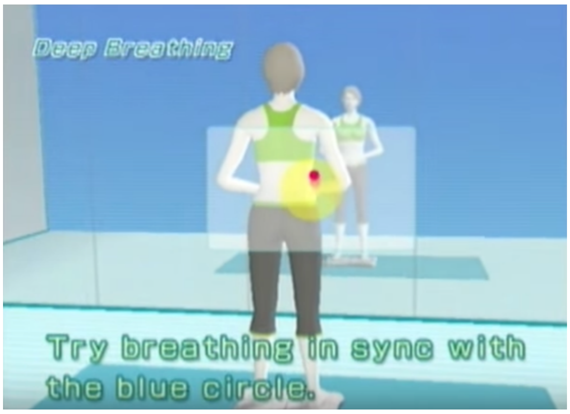


Figure 74

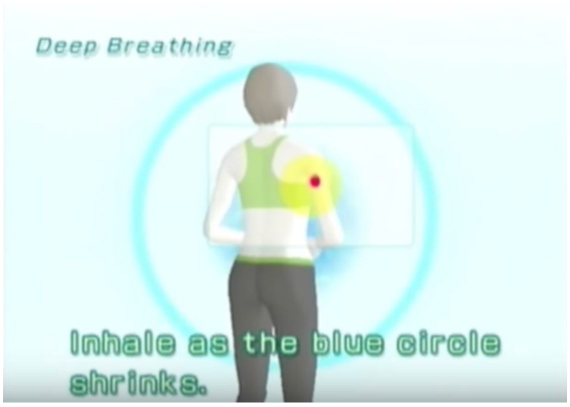


Figure 75

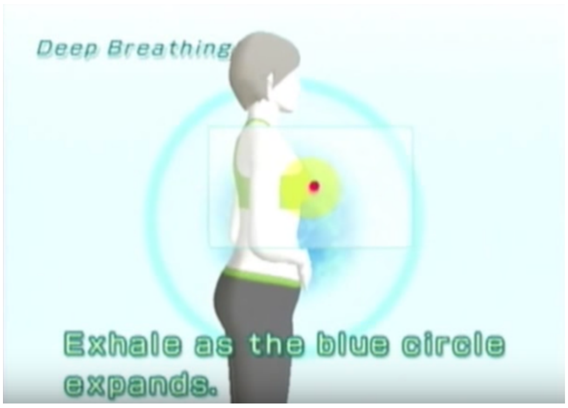


Figure 76

Figure 77

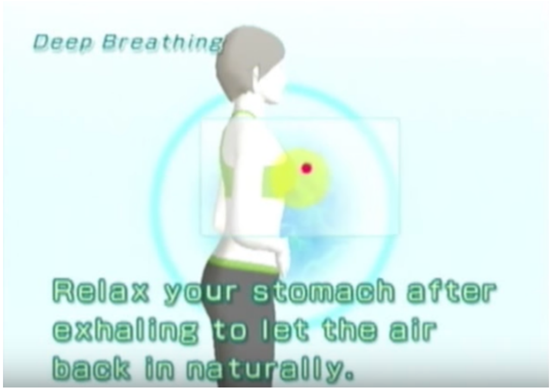


Figure 78

Figure 79

The Wii balance board is then used to record the centre of balance during the activity and a score is presented at the end.

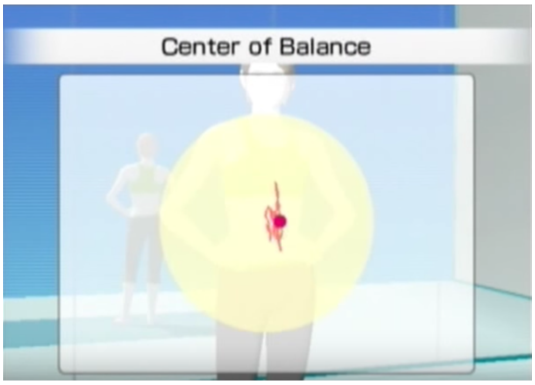


Figure 80

Figure 81

The instructor advises the participant based on their outcome score in order to improve the next time.

Figure 82

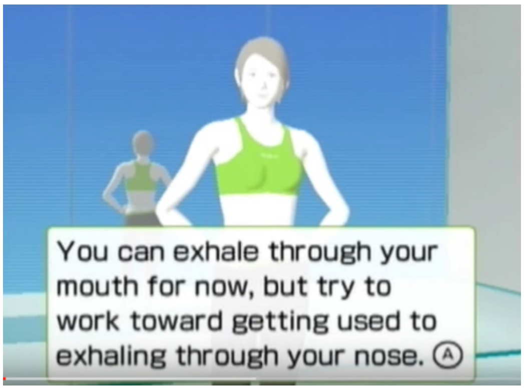


Figure 83

Figure 84

This yoga exercise merely consists of standing upright and breathing correctly and then centre of balance is assessed at the end. The greater the deviations from the centre point the lower the score will be. There are several other balance exercises that also include the breathing technique as part of it. Some poses are listed below with instruction from the instructor.

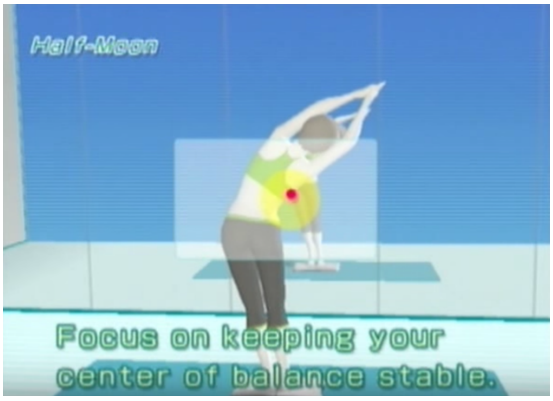


Figure 85

Figure 86

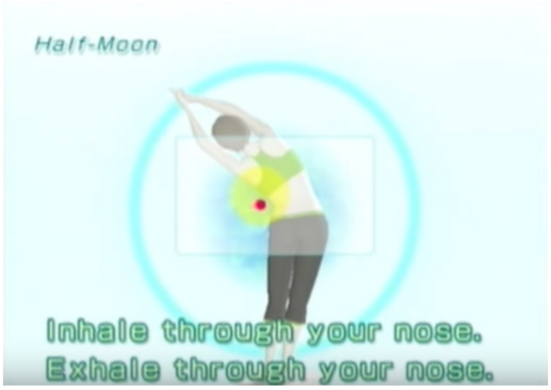


Figure 87

Figure 88

Figure 89

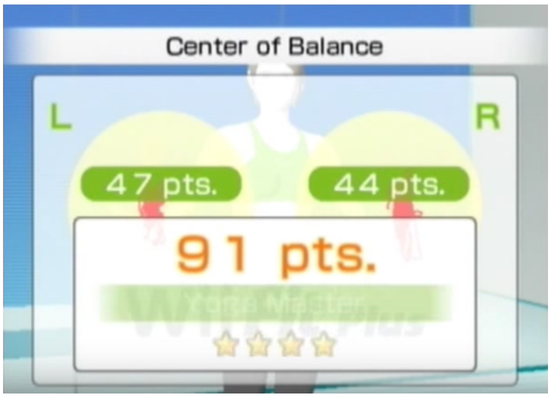


Figure 90

Figure 91

Figure 92

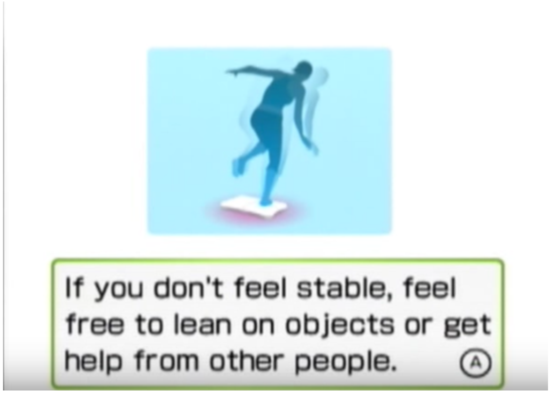


Figure 93

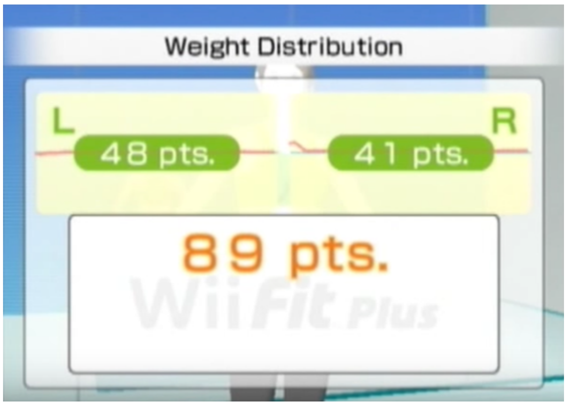


Figure 94

Tilt City – The setting consists of a background of a city scape at night with a starry sky with the moon. The Mii character is instructed how to tilt the platforms correctly and is rewarded when the correct ball goes into the correct pipe (colour). Points are awarded for getting one ball in after the other and the bonus points are given for getting the bigger balls with the other Mii characters faces on in the correct pipe.

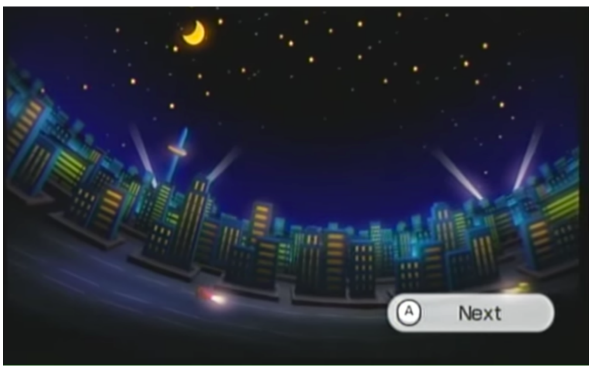


Figure 95

Figure 96

Figure 97

Figure 98

When the balls go in the right pipe, the pipe expels a ray of light in that colour upward and a point flashes in the air.

Figure 99

Figure 100

When the balls go in the wrong pipe, the pipe expels smoke and a sound is heard.

Figure 101

The game finishes when all 40 balls have been played and a score is presented to the participant based on number of balls made by points.

Figure 102

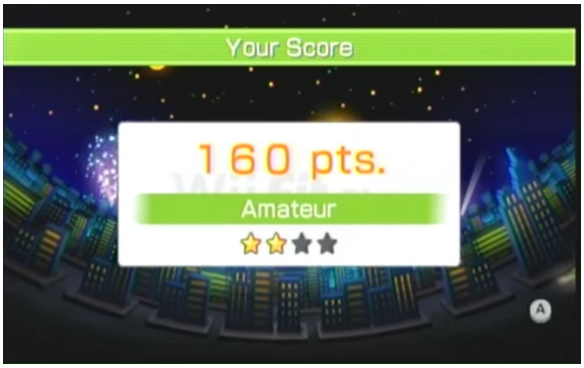


Figure 103

Snowball Fight – The environment is a snow covered arena with obstacles in the middle for the characters to hide behind. The Mii character starts hidden behind an obstacle and is instructed how to point, aim and throw snowballs whilst simultaneously avoiding incoming snowballs. If the participant is hit with a snowball, the on-screen vision is partially blocked by snow replicating being in the eyes of the participant. The participant has three lives and loses a life when being hit by a snowball but can also gradually gain a life back by not getting hit by snowballs. The game lasts for 90s and points are based on number of targets hit.

Figure 104

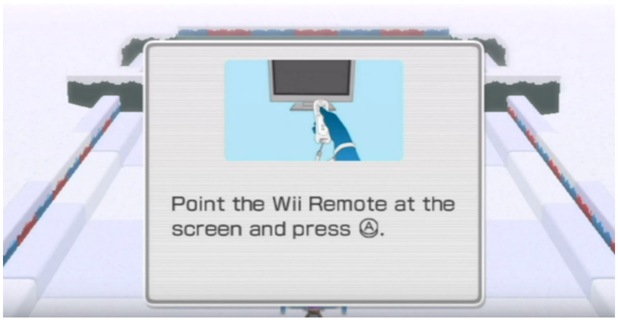


Figure 105

Figure 106

Figure 107

Figure 108

Figure 109

Figure 110

Figure 111

Figure 112

Figure 113

Perfect 10 – The Mii character is located in the middle of three mushrooms with some more mushrooms with characters placed around the outside of the playing space, cheering on the Mii character. The background is bright and colourful but does not represent any real life landscapes.

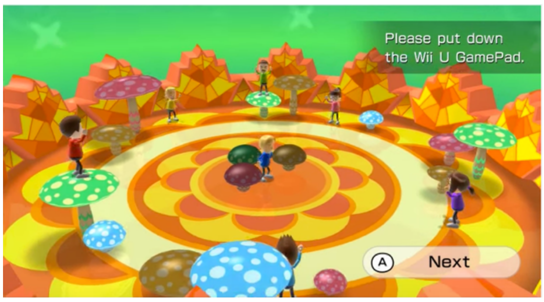


Figure 114

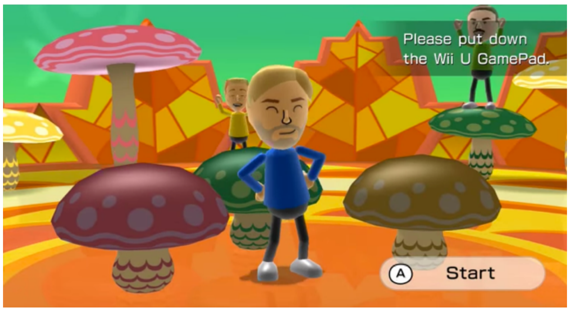


Figure 115

There is some on-screen instruction as to how to play the game. The objective is to shift weight side to side and backward to bump the mushrooms with the right numbers on that add up to 10. The number of times this is done is the score at the end.

Figure 116

Figure 117

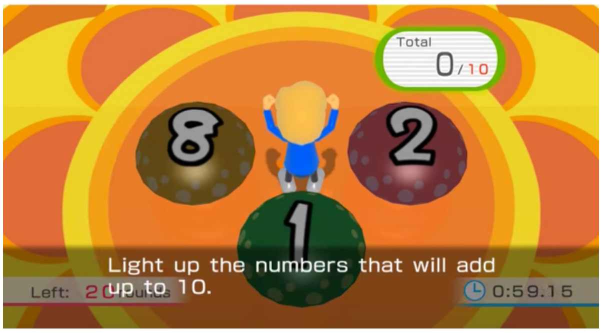


Figure 118

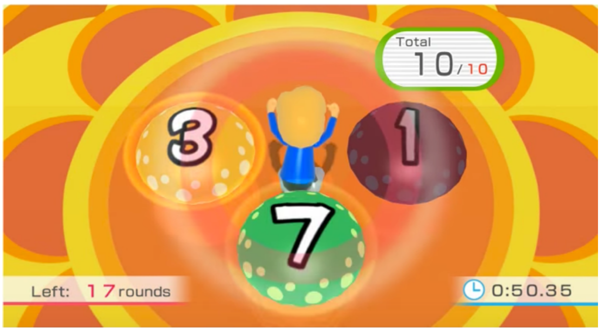


Figure 119

There are 20 rounds in the game. The Mii character celebrate when a few are scored correct in a row. At the end the score is displayed and the participant is rated amateur in this case as not all attempts were successful.

Figure 120

Penguin Slide - The Mii character is located in the middle of a flat iceburg with some more iceburgs in the background with characters on, cheering on the Mii character. The background is an ocean, a sky with clouds and iceburgs with penguins on top. There is some on-screen instruction as to how to play the game. The objective is to shift weight side to side and to catch the fish. Blue fish are 1 point, green are 2 and red are 10 points and are the hardest to catch. Red fish require faster and more controlled weight shifting patterns. The number of points is the score at the end.

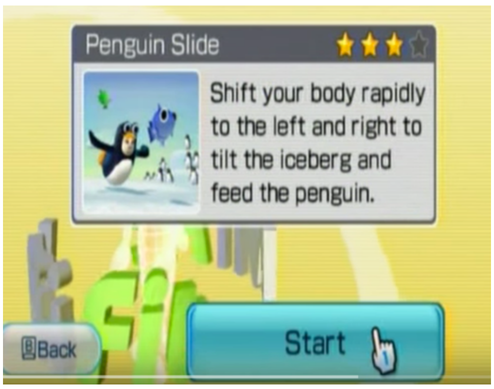


Figure 121

Figure 122

Figure 123

Figure 124

Figure 125

Nintendo Wii Sports: There are 5 sports to choose from which each resemble the environment (internal) of that sport: Bowling, Baseball, Boxing, Golf and Tennis.
Publications using some/ all of these games: Ray et al. 2012, Tange et al. 2012

Bowling - The Mii character is located at the top of the lane and behind are other Mii characters visible from the rear. The observed environment resembles a bowling alley. Before the Mii character is prepping to bowl, the camera pans across their front and shows other Mii characters behind waiting to play. The walls are blank in the background and there is a digital score card onscreen at the bottom.

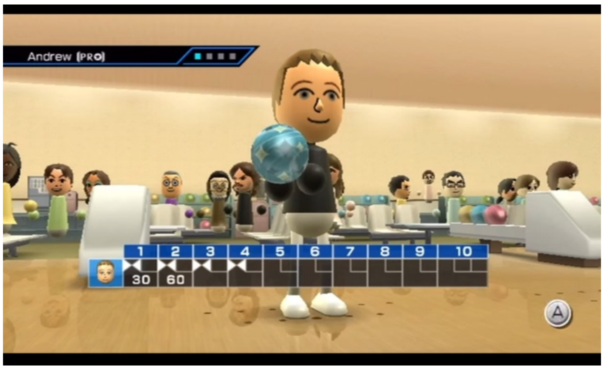


Figure 126

As the Mii character preps to bowl, a rear view is taken and the Mii character is slightly transparent. There is some instruction as to how to hold the controller and to move the character and how to bowl correctly.

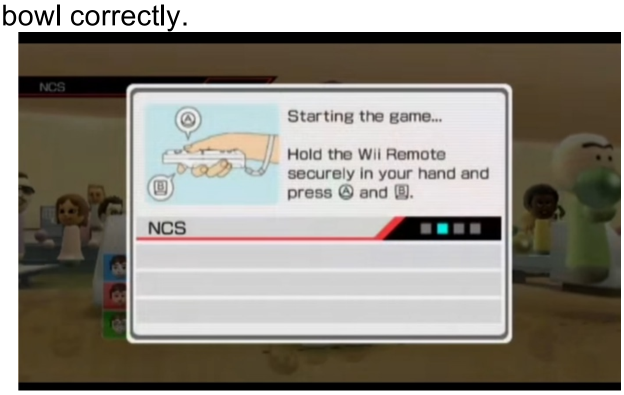


Figure 127

remote

Figure 128

Move player

Figure 129

How to bowl

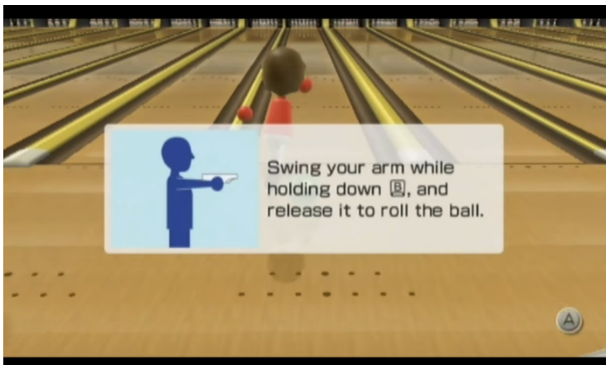


Figure 130

The bowling ball is then thrown and the camera follows it down the lane.

Figure 131

If successful, the screen shows either a strike, half strike etc. and shows the number of pins that have been knocked down

Figure 132

Figure 133

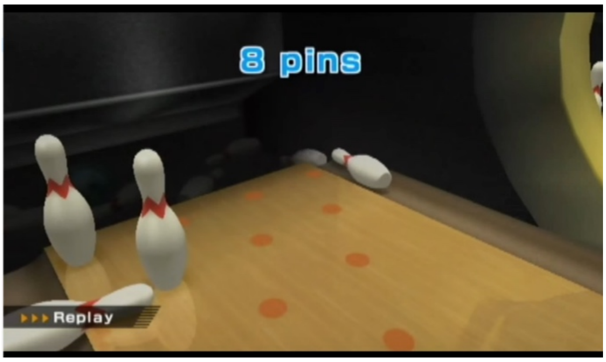


Figure 134

Figure 135

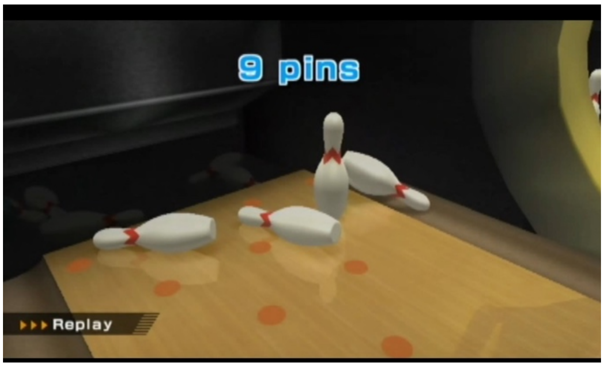


Figure 136

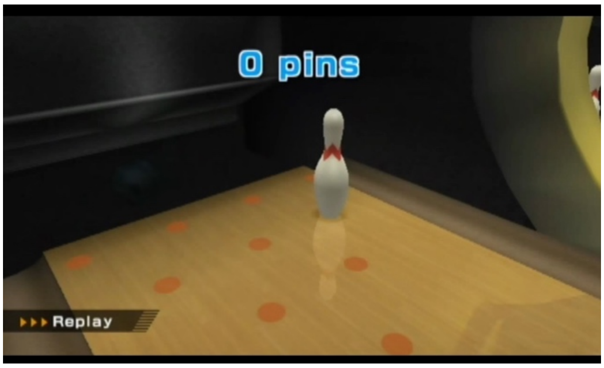


Figure 137

The table is shown at the end of the game as to whom has won the game and second place etc. with all the scores on the table board. A skill level graph is shown providing information about who was the most skilful (based on points).

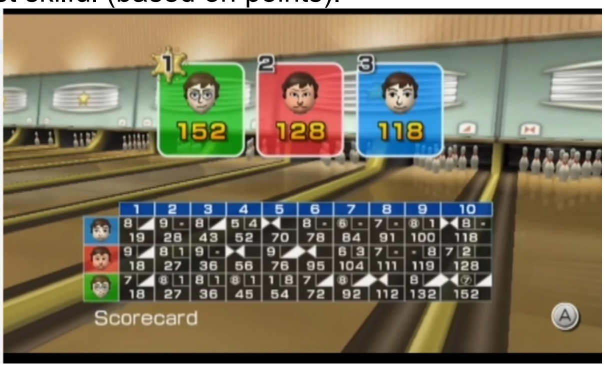


Figure 138

https://www.youtube.com/watch?v=KnQdHS5LA5o

Boxing - The Mii characters (player vs player or player vs computer) are located in a square boxing ring in the middle of a venue surrounded by a crowd. The venue looks typically like a boxing ring venue with lights shining down on the ring and screens around and above advertising Nintendo Wii.

Figure 139

At ring side, the observed environment are the two boxers in the ring and some screens in the background.

Figure 140

As the characters begin to box the screen splits so that each individual can view their Mii character from the rear and the two boxing gloves (hanging freely with no arms attached). It is possible to see the crowd in the background.

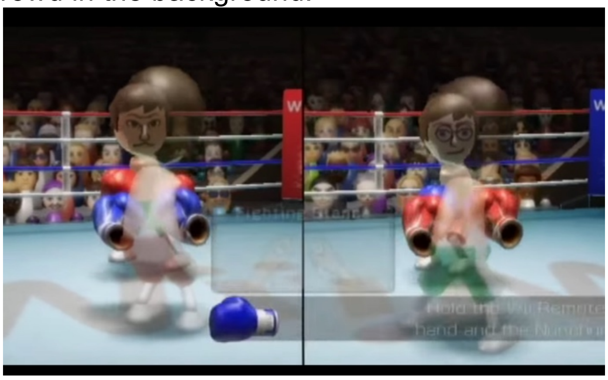


Figure 141

At this instance, instruction is given as to how to hold the controllers correctly for “fighting stance”

Figure 142

The fight starts once the fight sign flashes up.

Figure 143

The Mii characters then begin boxing and on either side of the screen there is a circle of strength split into ten segments that the opposing character attempts to beat down to zero against the clock. The background is a crowd. Each time a Mii character is punched, a segment of strength first flashes and then disappears. Depending on where the Mii is punched will vary the rate at which the strength segments deplete. There are three rounds to the fight. No movements instructed on-screen.

Figure 144

Once the last segment has been depleted the Mii character falls down to the floor of the ring and a countdown of ten seconds begins for the Mii to get back up before the fight is judged as a knockout.

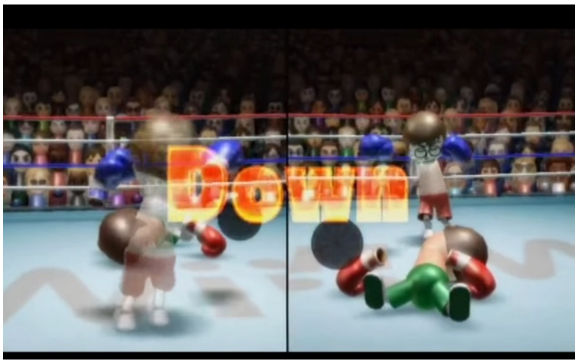


Figure 145

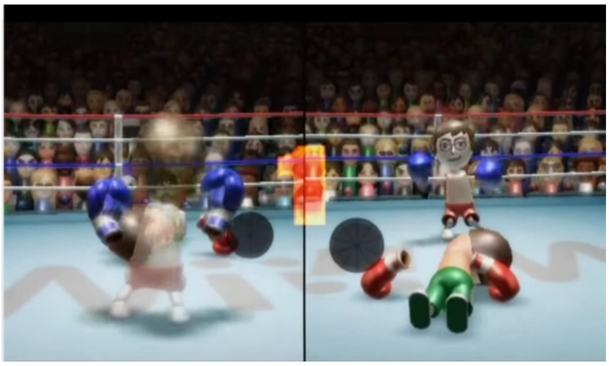


Figure 146

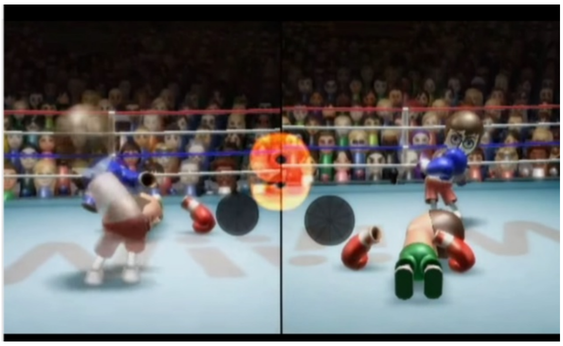


Figure 147

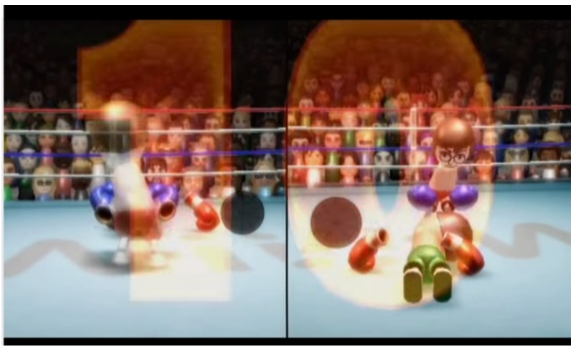


Figure 148

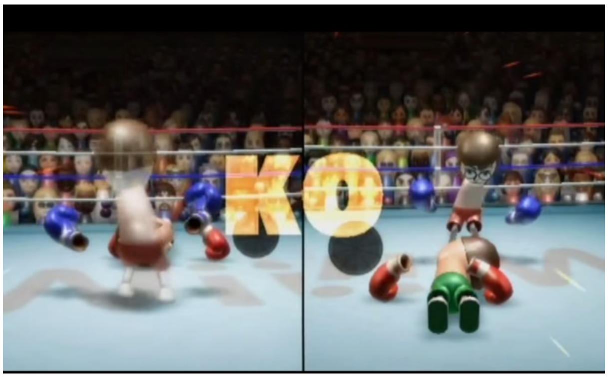


Figure 149

The winner of the fight is then celebrated with the crowd

Figure 150

Laptop plus Wii Balance Board: Unlike the Nintendo Wii interface, this setup consists of a laptop and a Wii balance board. The participant does not have an onscreen avatar in this game but still uses a balance board. "Tailor made balance games were designed so that they matched the action capabilities of older adults. By progressing through various levels of difficulty participants trained aspects of both static and dynamic balance, yet encouraged attention switching and dual tasking. There are four games in total: Apple Catch, Bubble Pop, Smart Shrimp and Avoid the Shark".
Publications using some/ all of these games: Merriman et al., (2015) (Apple Catch, Bubble Burst), Whyatt et al., (2015) (Apple Catch, Bubble Burst, Avoid the Shark, Smart Shrimp)

Apple Catch – The setting of the game consists of an apple tree in the middle of the screen and set in a field with green hill behind and a blue sky with small clouds. At the bottom of the tree is a basket which is controlled by the participant similar to the Mii character on the Nintendo Wii.

"The apple catch game is designed to specifically train and strengthen levels of dynamic and static balance during **a sway type task**. The participant must **sway to either the left or right side, and hold that position to "catch" apples** as they fall off the tree. To **focus attention** and help participants **anticipate where the next apple will fall**, the apple flashes for a few seconds on the tree. As well as this visual feedback component (i.e. seeing the apple fall in the basket), the game also includes an auditory feedback component. Sound effects were created that coincided with the apple landing in the basket. This auditory-visual coherence helps add a multisensory dimension to the task. Participants can see their score throughout the task and are also presented with their score at the end of each level, allowing both players and experimenter to see how well they performed. The presentation of the score provides a strong motivational component that allows direct knowledge of results, increasing levels of motivation and desire to improve on previous scores. The game contains 4 levels of difficulty where the speed and position from which the apples drop from the tree are varied to become progressively more difficult, pushing the balance control requirements necessary to succeed in the task.” From Extracted from **Craig et al., (2012)** as directed to for game description via **Whyatt et al., (2015).**

There appears to be no on-screen instruction or demonstrations during game play for the participant. The monitoring system and reward is just the score at the end of each game and COG tracking of the participant live during gameplay via the balance board.

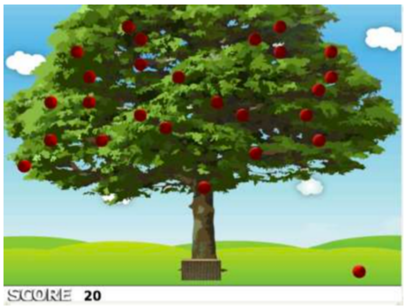


Figure 151

Change in participant movement requirements:

“The most notable change in the other 3 games (Bubble Pop, Smart Shrimp, Avoid the Shark) compared to the apple catch game is the additional movement axis. In these three games the participant must control the movement of the lobster (i.e. the position of their COP) in both the left-right and anterior-posterior axes to “pop” bubbles. Sound effects of bubbles ‘popping’ are also included when the participant successfully manoeuvres their COP to the target area (i.e. the bubble). To familiarise the users with the game, the first level of Bubble pop contains static bubbles. Once they have become accustomed to the movement of the lobster bubbles start to rise up from the bottom of the screen. In addition, the spatial and temporal requirements of the game increase as the participant progresses through the levels of difficulty, with bubbles appearing in the extremities of the screen. As with the Apple Catch game these increased task demands can only be attained with better balance control. Likewise the score in the game represents the number of bubbles popped, again providing direct knowledge of results to enhance learning and performance” Extracted from **Craig et al., (2012)** as directed to for game description via **Whyatt et al., (2015).**

Bubble Pop – The setting of the game is on the ocean floor. There are coral reefs and fish swimming around in the background. The participant is represented by an on-screen lobster.

Figure 152

There appears to be no on-screen instruction or demonstrations during game play for the participant. No tutorial although this could be given by the researcher. The monitoring system and reward is just the score at the end of each game and COG tracking of the participant live during gameplay via the balance board.

Avoid the shark – The setting of the game is the same as Bubble Pop except a shark is to be avoided. There are coral reefs and fish swimming around in the background. The participant is represented by an on-screen lobster.

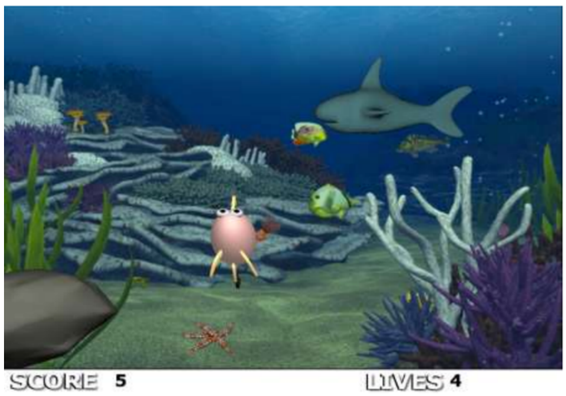


Figure 153

"To add complexity to the initial bubble pop game the "avoid the shark game" was developed. This time participants had to "hide" from a shark that swims periodically across the screen. This requires the participants to spot the shark and then switch their attention from popping the bubbles to moving their COP to a prescribed location (i.e. the rock) so they can avoid being eaten. This additional component to the game requires the participant to now hold a stationary position thus training their static balance. Again, as progress is made through the game levels the dynamics and location of the bubbles change, as well as the position of the rock changes. As before this increases the complexity of the task requiring more sophisticated postural control to be able to succeed in playing the game. Again game score also reflects performance". Extracted from **Craig et al., (2012)** as directed to for game description via **Whyatt et al., (2015).**

There appears to be no on-screen instruction or demonstrations during game play for the participant. No tutorial although this could be given by the researcher – check this!! The monitoring system and reward is successfully avoiding the shark and simultaneously popping as many bubbles as possible for a score at the end of each game and COG tracking of the participant live during gameplay via the balance board.

Smart Shrimp – The setting of the game is the same as Bubble Pop and Avoid the Shark.

Figure 154

"In the final game we introduced a brain training component, where the users had to complete a simple sum, or solve a word completion task by identifying the bubble with the correct answer in it and pop it, whilst avoiding all the other bubbles with the wrong answer. This cognitive, or brain training component, encourages the participant to dual task, a factor that has been found to significantly impair balance performance in older adults. In addition to the cognitive challenge, the size of the bubbles in this game is smaller, forcing the participant to be more precise in the control of their COP. This dual task game was the most challenging game both spatially, temporally and cognitively, which meant it was challenging for even the most advanced players". Extracted from **Craig et al., (2012)** as directed to for game description via **Whyatt et al., (2015).**

There appears to be no on-screen instruction or demonstrations during game play for the participant. No tutorial although this could be given by the researcher – check this!! No clues or help on-screen with sums or word completion. Reward is getting sum or word correct.

Xbox Kinect: "The intervention game content used Kinect and Kinect SDK version 1.5 (Microsoft) and Unity version 3.4.2 (Unity Technologies SF Inc., San Francisco, CA), a three-dimensional (3D) support tool/engine used with Kinect" **Sato et al., 2015.** There are 4 games to play: Apple Game, Tightrope standing, Balloon Popping and One-leg Standing.

Publications using some/ all of these games: Sato et al., 2015

Apple Game: This setting is similar to that of "Apple Catch" but this time there are two apple trees, green hills, blue sky and there is an avatar instead of a basket representing the participant on-screen. **"**In the apple game, targets resembling apples were distributed on a 3D coordinate system around the participants, who were instructed to use both arms to grab them. The game lasted for 90 seconds and included three levels of difficulty. At the easy level, participants were able to grab apples without much movement. However, as the level of difficulty increased, the targets were more widely distributed" Sato et al., (2015).

Figure 155

As there is no access to the live gameplay videos we have to rely solely on images and descriptions in-text. There appears to be no on-screen instruction or demonstrations during game play for the participant from the images, although there is Japanese writing at the bottom and a number indicating a score. No tutorial, although this could be given by the researcher. There are two types of visual immediate feedback: via the avatar and viewing live-self during gameplay.

Tightrope Standing Game: The setting displays a river with a log protruding out that the participant stands on. There is a blue sky with clouds in the background. The participant can see themselves on-screen as well as the avatar.

"In the tightrope standing game, participants had to place their feet along a straight line and stand as if they were standing on a tightrope (tandem standing). Similarly to the apple game, targets were distributed laterally and in front of the participants, who were instructed to grab them at specified times. The game lasted for 90 seconds and included three levels of difficulty" Sato et al., (2015).

Figure 156

As there is no access to the live gameplay videos we have to rely solely on images and descriptions in-text. There appears to be no on-screen instruction or demonstrations during game play for the participant from the images, although there is Japanese writing at the bottom and a number next to it indicating a score. No tutorial although this could be given by the researcher – check this!! There is an immediate feedback mechanism via the avatar and viewing self during gameplay.

Balloon Popping: The setting displays the sea in the background with a palm tree on a grassy knoll. There is a blue sky with clouds in the background. The participant can see themselves on-screen as well as the avatar from frontal and sagittal standpoints.

"In the balloon popping game, targets resembling balloons moved in an arc over the game screen in front of participants, who were instructed to pop them when they passed through the area where their buttocks were by bending their hips and knees and squatting down. The game lasted for 40–90 seconds and included four levels of difficulty. At the level of difficulty increased, the angle of knee bending required to pop the balloons increased, as did the number of balloons. Furthermore, the sensor acquired hip bending angle data during squatting, and an alert message, reading ''bend more,'' was displayed when the angle was insufficient" Sato et al., (2015).

Figure 157

As there is no access to the live gameplay videos we have to rely solely on images and descriptions in-text. There is some on-screen instruction via live tracking from the Kinect. There is Japanese writing at the bottom and a number next to it indicating a score. No tutorial although this could be given by the researcher – check this!! There is an immediate feedback mechanism via the avatar and viewing self during gameplay.

One-leg Standing: The setting displays a flat plain concrete surface (maybe grass in distance). There is a blue sky with clouds in the background. The participant can see themselves on-screen as well as the avatar from frontal and sagittal standpoints.

"In the one-leg standing game, participants were instructed to stand on one leg and use their knee to touch a ball that appeared in front it. Targets popped when participants touched them with the specified knee at the specified time. At the level of difficulty increased, the knee position became higher, and time that participants were required to hold the position increased. Furthermore, the sensor acquired hip bending angle data, and an alert message, reading ''lift higher,'' was displayed when the angle was insufficient" Sato et al., (2015).

Figure 158

As there is no access to the live gameplay videos we have to rely solely on images and descriptions in-text. There is some on-screen instruction via live tracking from the Kinect. There is Japanese writing at the bottom and a number next to it indicating a score. No tutorial although this could be given by the researcher – check this!! There is an immediate feedback mechanism via the avatar and viewing self during gameplay.

Xbox 360 Kinect: An Xbox 360 Kinect (Microsoft Corporation, Hong Kong) was used. An exergame called "Tiger Woods PGA Tour 13" was adopted in the training sessions. The 10 hole gaming mode was selected.

Tiger Woods PGA Tour 13: The game characteristics were not described in the article nor were the types of movements that occur during gameplay. "Standby assistance and demonstration of the golf swing were given at the beginning of and during the demonstration sessions" Chow and Mann., (2015).

The setting is a green grass golf course with a blue sky and trees in the background. There are areas taken up by crowd watching near each hole.

The types of movements that occur during this game from observing videos on Youtube are: upright standing, trunk flexion, forward lean, side-to-side weight shifting with rotation of the hips and shoulders, knee flexion and extension, shoulder adduction/abduction.
https://www.youtube.com/watch?v=mFYruHmzas0 accessed on: 01/03/2017.

Figure 159

Xavix Measured Step System: "The Xavix Measured Step System (XMSS), from Japan, was used to perform the IVGB exercises The XMSS contains 1 console (Xavix port), an A/V cable connected to a television, a power cable connecting the console to a power source, and a 1x4 one-step mat. A USB cable connected a custom Xavix computer software cartridge to a computer. Results were recorded using personal cartridges" Lai et al., (2013).

Publications using some/ all of these games: Lai et al., (2013)

This is the only instruction apparent and was given to the participants via the lead researcher. "During exercise, to ensure uniformity in exercise posture, participants were asked to raise their knees above their waists, maintain their trunks in an upright position, and avoid too much compensation by postural sway while performing the stepping exercise". The publication failed to describe the games used in the study. The following information was obtained from http://xavixstore.com/shopping/applications/xavix-j-mat/. Accessed on the 01/03/2017.

This system uses a famous actor as the on-screen instructor. "Step up your cardio fitness with a trainer who knows all the right moves- Jackie Chan. With the System Cartridge and wireless J-MAT, it's like you're in Jackie's fitness studio". The system will track workout times and calorie burn. The J-MAT software is divided into three zones – Cardio Exercise Zone, Running Zone, and Agility Zone. Each of these zones has a different user interface.
http://www.xavixstore.com/products/users_guide/mat_ug.pdf
Accessed on 02/03/2017

Cardio Exercise Zone
Step Lively:
An aerobic workout with an on-screen instructor (Jackie Chan). Choose between three levels: Easy, Intermediate and Advanced. There are 10 song options to choose from in each level, each with a different pace and rhythm. The 21 combinations of available aerobic step patterns are related to the aerobic steps shown on screen, and differ according to the difficulty level and the music you choose.

In the MODE SELECT screen, select Step Lively at CARDIO EXERCISE ZONE, and step on ENTER. The STEP LIVELY screen will be displayed.

Select the desired difficulty level using BACK or FORWARD, and step on ENTER. The cursor will move to music selection. Select from the various available music.
You can select from just 1 tune up to 10 tunes in 6 stages — 1, 2, 3, 5, 7 and 10 tunes. If you want a light workout, select 1, 2 or 3 tunes. If you want a hard workout, select a larger number of tunes.

Step on ENTER to start your Step Lively workout. The screen on the left will be displayed.

Each workout in Step Lively is made up of a Warm Up period, the Step Lively workout, and a Cool Down period. The Warm Up and Cool Down periods last 40 seconds each.

You will see Jackie standing in front of you in his fitness studio. He is your instructor, and will instruct you how to move in rhythm with the music. So, follow Jackie's movements.

Figure 160

In Step Lively, there are 21 aerobic step patterns:

- Jump
- March
- Slide
- Knee Up
- Open-Close
- Open-Close Jump
- Back Lunge*
- Foot-Lookin'
- Elbow-Touch
- Cha-Cha-Cha
- Side Step A
- Side Step B
- Leg Curl
- March Jump
- Side Step & Stretch
- Cross
- Side Kick
- Heel Touch Variation*
- Back Kick
- Knee Up Variation*
- Front Kick Variation*

A warm up and explanation of difficult step patterns is described in the user manual. This is not explained in the study by Lai et al., (2013) and it is not known if the participants had this information. The author has been contacted but with no response.

Knee Up Variation:

You start this step standing upright with both of your legs together. Lift up one knee and rise up from your other foot as if to jump up slightly so that your center of gravity rises. When you do this, use the cushioning effect of the J-MAT to steady the foot you are supporting your body weight on. Keep your posture so that the small of your back is kept in and does not round out. At the same time, swing and extend your arms naturally and in rhythm with the movement of your legs. Now do the same with your other leg.

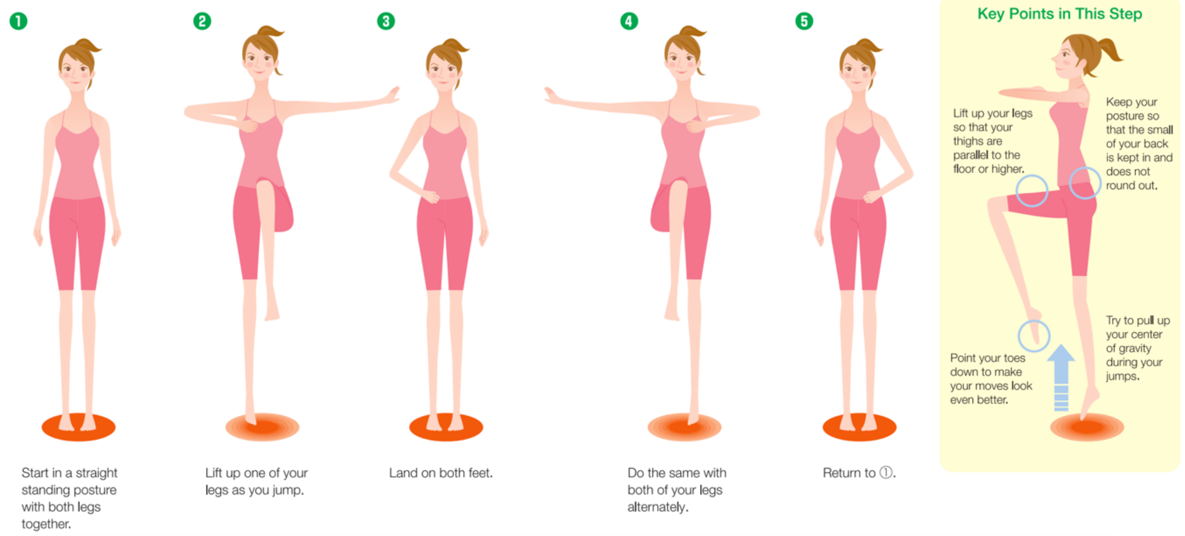


Figure 161

Back Lunge:

You start this step standing upright with both of your legs together. Extend one of your legs backwards to step back and move your center of gravity onto that leg making sure not to make any big movements to the side or front. Immediately return to your original stance and bring your legs together. Next, do the same but with your other leg making sure that your body is leaning forward and a straight line is formed from your head to your heel. In this pose, stretch the leg that you extended behind you.

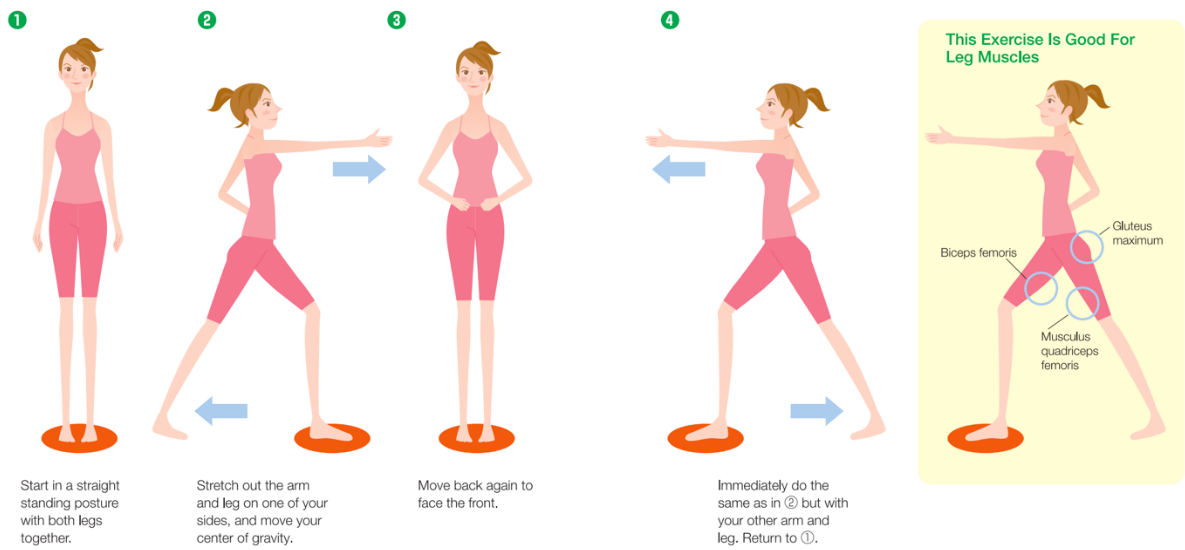


Figure 162

Front kick variation:

This step pattern is like Side Kick except that you exercise with a series of light jumps.
You might not be so good at this pattern when you first try it. However, once you get the hang of the moves, you will be able to master it if you remember to keep your balance. So stick at it and don't give up!

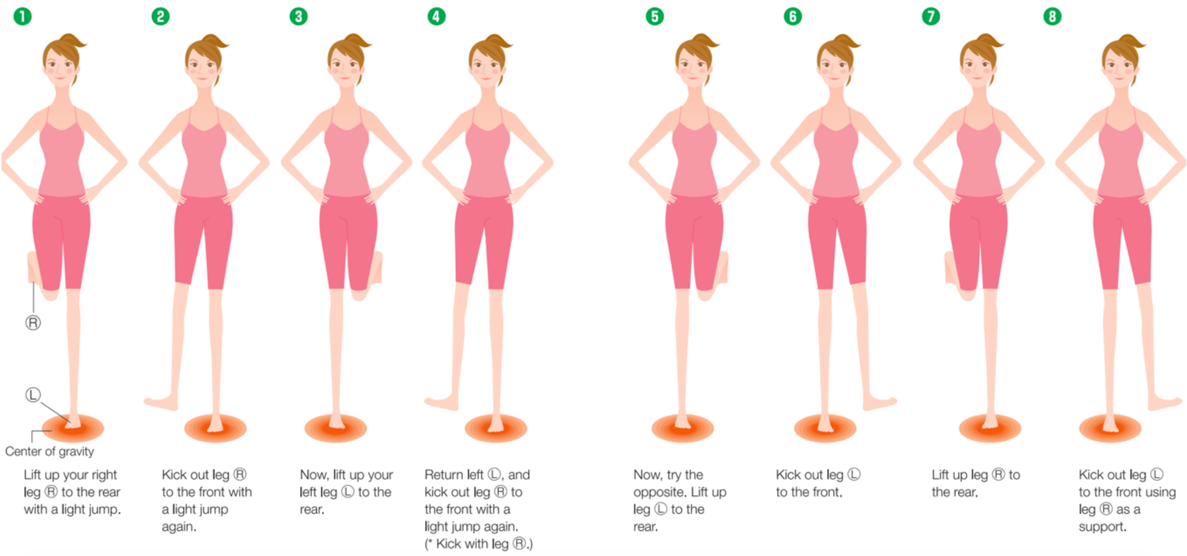


Figure 163

Heel touch variation

This exercise involves big rhythmical movements.

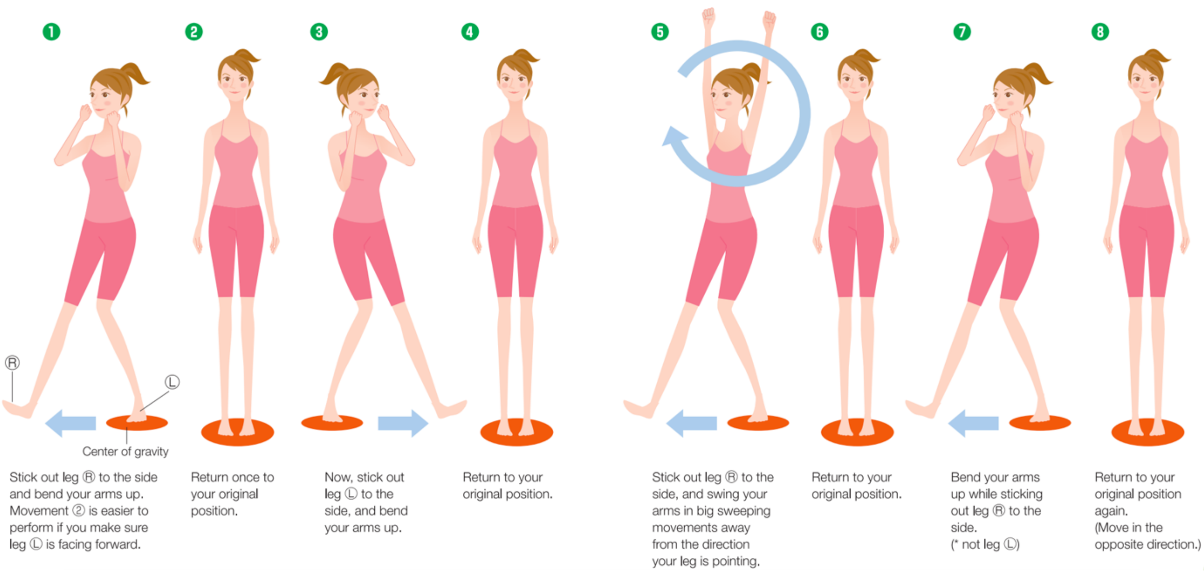


Figure 164

Each combination of these patterns differs according to the difficulty level and the music you choose.

After the Step Lively workout, you then have a Cool Down period. FINISH is then displayed on screen.

Your performance is then added to the log screen and displayed.

Note

About ♪

When you are selecting music in Step Lively and Vigorous Step, you will notice that each title is followed by musical note marks ♪. This shows the pace of the music. ♪ indicates a relatively slow pace while ♪♪♪♪♪ is for the fastest paced music available in the J-MAT software. The more ♪ there are, the more calories you will burn as you will have to move that much faster.

About the Cal Display

In Program selection, the expected number of calories you will burn up is displayed based on your registered user data. The number of calories you burn is calculated based on the measurement data in a standard state, and may differ from the actual number of calories burned.
So, enter your personal information accurately as the number of burned up calories that is displayed changes if your registered user information (age, sex and weight) changes.

Figure 165

Note

About Step Timing

Just like in real aerobic exercise, the timing that you move in rhythm with the musical accompaniment is important.
With J-MAT workouts and action, the step timing is important, too, as your performance is rated by the number of successful steps. Missteps are allowed but the more missteps you make means that your overall performance will drop.

Stepping on a pad in this state will result in a misstep.

If you step on the right-side pad just when the blue ball touches the J-MAT, you will be too late and this will be regarded this as a misstep.

Stepping on a pad in this state will result in a successful step.

However, if you step on a pad while the blue ball is falling down about two thirds down the screen, this will be regarded as a successful step and will go towards your result.

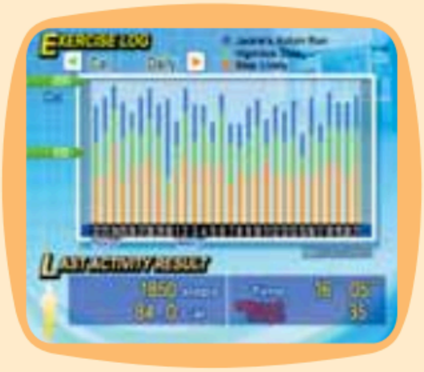
Even if you make lots of missteps, do not let this bother you as this is not a competition and you are not competing against anybody!

So that you can get practice and a good idea of the step timing in J-MAT workouts and action, why not try a workout at Guest in the USER SELECT screen?
With Guest, your performance will not be saved to log screens.

Figure 166

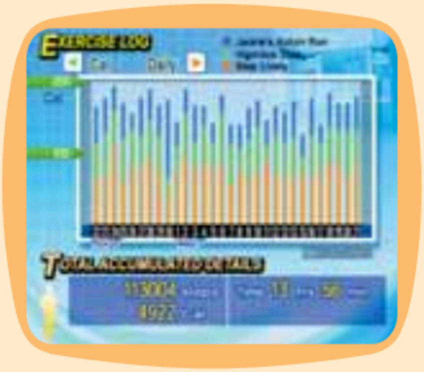
Note

About the Log Screen

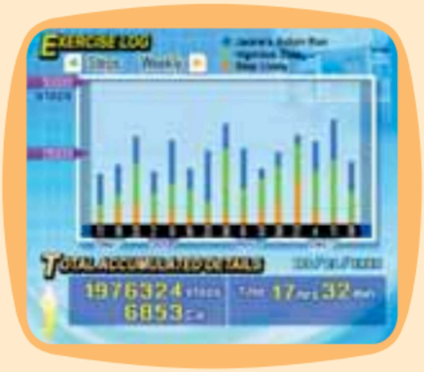


The log screen is displayed each time you finish Lively Step, Vigorous Step and Jackie's Action Run. This screen is a record of your past performance, and is displayed in a different color.

This screen displays the number of calories you burn in a single session, total number of steps and time. This log graphically shows you how much you are improving as you advance and accomplish more difficult workouts. You can also change how the display is represented, on a daily, weekly or monthly basis.



Daily display



Weekly display

If you are unhappy with the results of your workout and you do not want to log your score, or something prevents you from completing the workout, you can forcibly exit the workout by pressing the RESET Switch on the PORT. This way, your score will not be saved to the log.
This is possible until Cool Down ends, and you step on ENTER while Step on ENTER is displayed.

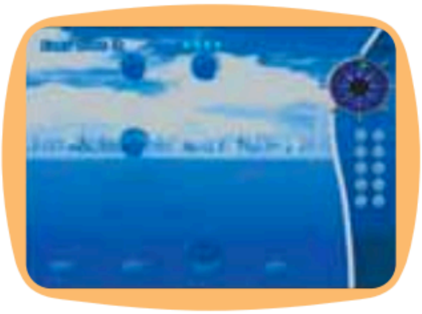
Figure 167

Vigorous Step:
This area is for those who just want to move in time with invigorating music and have fun. There are four levels to choose from, beginner, intermediate, advanced and professional.

Access to the professional level requires a high standard of performance at advanced level. Song options are shorter in duration and fixed to 90s in length.

In the MODE SELECT screen, select Vigorous Step at CARDIO EXERCISE ZONE, and step on ENTER. The VIGOROUS STEP screen will be displayed.

Select the desired difficulty level, and step on ENTER. The screen will change as shown on the left.



Now, enter the desired music. Tunes in Vigorous Step are short and fixed to about 1.5 minutes in length.

Step on ENTER to start Vigorous Step action.

The backdrop is Hong Kong harbor at night and you are facing its "Million Dollar Sunset."
As you go through the workout, the green gage in the ship's wheel advances to show how much time you have left. Also, the number of blue balls under the ship's wheel decreases each time that you make a misstep. In Vigorous Step screens, you are allowed up to 10 missteps.

Figure 168

Shows how much time is left.

Shows how many misstep chances are left.

When you finish a workout, a message showing how you performed will be displayed.

This screen is then followed by the log screen, and you can return to the VIGOROUS STEP screen.

Note

About Getting Extra Blue Balls

- Eight continuous successful steps are regarded as an OK.
- If you made eight or more continuous successful steps, you will get extra blue balls (one extra blue ball for each successful step in excess of eight).
- Seven or less continuous successful steps are regarded as a misstep.

Figure 169

Running Zone
Jackie's Action Run:
In this area, the participant is Jackie Chan (acting as an on-screen avatar) and the participant travels through the streets of downtown Hong Kong in a 5-minute workout consisting of walking, running, jumping squat and side step. There are three levels to choose from,

beginner, intermediate and advanced, each five minutes in duration. There is a tutorial that teaches the basic movements. The participant has to perform the movements whilst avoiding obstacles on-screen.

In the MODE SELECT screen, select Jackie's Action Run at Running Zone, and step on ENTER. The JACKIE'S ACTION RUN screen will be displayed.

We recommend first-time users or budding action stars to try out Tutorial as you will have to remember the various combinations of J-MAT movements to successfully avoid obstacles and "ninjas," and complete the action run course.

Select "Tutorial" and step on ENTER to start the tutorial. Messages will appear on screen instructing you how to move on the J-MAT to perform a certain action.

For example

To shift to the left, jump to the two pads to the left simultaneously.

To squat, crouch and touch the gray pad(s) to your side(s).

Figure 170

Figure 171

The following table summarizes the movements you must remember in Jackie's Action Run.

Standby	Stand on the two center pads.
Walk	Move your legs one after the other.
Run	Move your legs one after the other faster.
Shift (right)	Jump to the two pads to your right.
Shift (left)	Jump to the two pads to your left.
Shift (side to side)	Jump to the two pads from side to side.
Jump	Jump up off the J-MAT.
Squat	Touch the gray pad(s) to your side(s).

After you have finished the tutorial and are familiar with the various movements, let's start an actual action run.
Select the desired level — Beginner, Intermediate, Advanced — in the JACKIE'S ACTION RUN screen, and step on ENTER.

The screen will display "Standby" so get ready. If you like, you can do some limbering up exercises like Jackie is doing on screen. The screen counts down 3 ... 2 ... 1, and then you start the action run.

Though it may look easy at first glance, we recommend limbering up and stretching before you actually start the action run.
For details on limbering up exercises, see pages 48 and 49.

Figure 172

On screen you are Jackie, and you must move like Jackie does. During the action run, various messages appear on screen to prompt you to move in a certain way.

In this screen, you have to squat.

You will also be confronted by various obstacles that you must avoid.

For example

Shift left to dodge the road sign and shift right to dodge the "ninja" assassins.

At the end of the run, your score will be displayed.
This screen shows the number of action points, Ninja points, total points, and action star ranking (A to E).

This screen is then followed by the log screen.

Figure 173

Agility Zone
This area is designed so that you can test and improve your physical capabilities while simply having some fun with friends and family. In this zone, the amount of calories you burn up and other information are not displayed.

Dash:
Number of steps in 10 seconds. Records are recorded if the participant ranks in the top 10. No image available.

In the MODE SELECT screen, select AGILITY ZONE Dash and step on ENTER. The DASH screen will be displayed with a brief description of the aim of DASH.
As its name implies, the object of DASH is to see how many times you can step on the two center pads in 10 seconds by running on the spot as fast as possible.

Step on ENTER. The screen will change as follows.

The screen shows the J-MAT with the two center pads highlighted in blue. These pads are where you should be standing. It also shows the record score to beat.

The screen automatically starts the countdown with Ready? So, get on your marks, get set and get ready to start running when the prompt changes to GO!

Figure 174

The clock at the top right of the screen counts down while the counter in the center of the screen counts your steps.
When you finish, Finish! is displayed, followed by the RANKING screen even if you did not make it into the top 10.

Step on ENTER. You will then be prompted to continue. If you step on CANCEL, the screen will return to the MODE SELECT screen.

Figure 175

Reflex:
Test how long it takes you to react to the on-screen prompt to jump as quickly as possible. Your ranking will be recorded in the log if the average of your three trials is in the top 10.

In the MODE SELECT screen, select Reflex and step on ENTER. The REFLEX screen will be displayed with a brief description of the aim of REFLEX.
As its name implies, the object of REFLEX is to test your reflexes.

The interface and how screens progress are very much like the DASH screen.

Except, with REFLEX, you have three attempts to test your reflexes, and this is displayed at the top right of the screen as 1st trial, 2nd trial and 3rd trial.
When you see Ready?, get ready and jump as soon as JUMP! appears on screen.

In this example, it took you only 0.243 seconds to jump.
Now, get ready for your 2nd and 3rd attempts.

If you jump too early, the following screen will be displayed.

From here on, screens progress just like in DASH and display your ranking if the average of your three trials is in the top 10.

Figure 176

The user manual can be accessed here:
http://www.xavixstore.com/products/users_guide/mat_ug.pdf

Information from a amazon customer review here (for insight):

https://www.amazon.com/Xavix-J-mat-Cartridge/dp/B000GD8UKI

“The four panels on the mat not only match the stepping locations on the screen, but also serve as the function keys to add your age, weight, workout type, etc. Jackie Chan is your

instructor but gives no verbal cues, unlike an aerobic class. To keep your rhythm, these dots slide/ drop down the screen and when you step on the correct segment of the mat the dots bounce and/or change color. So, once you get the rhythm, you have a steady dot bounce. This program not only gives you an excellent aerobic work-out, as good as my step class, it works with your coordination skill with the colored dots, unlike my step class. If you're off rhythm
just a bit in class, you don't notice, but it's obvious with this program”.
Accessed on 01/03/2017.

Consoles and exergames used in the 6 additional publications obtained between April 2016 – December 2017.

Nintendo Wii + Wii Balance Board: “The Nintendo Wii consists of a console, a nun chuck and a balance board.”

Exergame: “EA Sports Active” – The games/ workouts are categorised into Cardio, Upper, Lower and Sports. Boxing, Walking, Running, Knee ups and kick ups, Inline skating, Dancing, Baseball, Volleyball, Tennis, Biceps curls, Triceps kickbacks, Shoulder raises, Bent over rows, Lunges squats

Levels: Easy, medium and hard

Publications using some/ all of these games: Boon Chong & Yong Hao. 2016, Monteiro-Junior et al. 2017.

The Boon Chong & Yong Hao. 2016 publication referred the reader to a supplementary file which included the games and movements used in both intervention groups. The Monteiro-Junior et al. 2017publication referred the reader to a previous publication. However, movement characteristics were not described in the publication for each game.

The following information was obtained from:
https://www.nintendo.com/games/detail/QYDk4d8GSJeoLkDWoebdKiHa5g9OjpLp
accessed on the 13/12/2017.

“Revolutionize your workout regimen with EA SPORTS Active, the ultimate interactive fitness program that’s designed for you. Get fit with a holistic approach to fitness that combines nutrition and lifestyle factors, with a variety of activities, all from the convenience of your living room. From customized routines that target upper body, lower body, and cardio to a guided 30-day challenge that tests muscle endurance, coordination and agility, stay in shape with fitness made fun and easy”.

“Active Fitness Made Fun & Easy— Pre-made circuits feature a variety of familiar activities that target upper body, lower body as well as cardio. Start off with a light jog, followed by bicep curls and get your heart beating with some cardio boxing”.

“Benefit of a Virtual Personal Trainer— Your trainer will be the focal point of the experience guiding you towards your own version of personal achievement. Feedback will be given throughout your workout, keeping you on track to reach your fitness goals”.
“The 30 Day Challenge— Take the 30 Day Challenge and experience tailor made workouts to your level of fitness. Circuits will change as you progress each day, and EA SPORTS Active

will track calories, intensity and progress throughout your journey. New Way to Play— Slip the Nunchuk into the specially designed leg strap and hold the Wii Remote in your hand to track your movements from both your upper and lower body. A resistance band is also included to increase the intensity of exercises such as bicep curls and shoulder presses.
Workout Your Way— Circuits can be customized to your interest and fitness level. Choose your duration, intensity level & set your own goals for calories burned and workout score.
Workout with a Friend— Burn calories with a friend as you both workout through routines together in a co-operative mode.
Track Your Progress— Expand your Fitness IQ and keep track of your workouts inside and outside of EA SPORTS Active with the in-game Journal.
Wii Balance Board Compatibility— Get more out of your EA SPORTS Active workout using the Wii Balance Board with added functionality for many of exercises".

Cardio exercises

Instructions, environment and movement characteristics can be viewed here:

https://www.youtube.com/watch?v=Om--WIxvyI0

https://www.youtube.com/watch?v=uVu6w7Sb-vE

Tennis

Instructions, environment and movement characteristics can be viewed here:

https://www.youtube.com/watch?v=AAnraOIFzdU

https://www.youtube.com/watch?v=B5staKDAfyU

Volleyball

Instructions, environment and movement characteristics can be viewed here:

https://www.youtube.com/watch?v=2U-hAE0-9d4

https://www.youtube.com/watch?v=uVu6w7Sb-vE

https://www.youtube.com/watch?v=B5staKDAfyU

Baseball

Instructions, environment and movement characteristics can be viewed here:

https://www.youtube.com/watch?v=B5staKDAfyU

Basketball

Instructions, environment and movement characteristics can be viewed here:

https://www.youtube.com/watch?v=B5staKDAfyU

Boxing

Instructions, environment and movement characteristics can be viewed here:

https://www.youtube.com/watch?v=hesWjy-80f8

Inline Skating

Instructions, environment and movement characteristics can be viewed here:

https://www.youtube.com/watch?v=ffDUDQaOuf8&t=53s

Dancing (Step aerobics)

Instructions, environment and movement characteristics can be viewed here:

https://www.youtube.com/watch?v=um5bzG6NJ2I

Lower Body Workout

Instructions, environment and movement characteristics can be viewed here:

https://www.youtube.com/watch?v=89hXxxb5Kc4

https://www.youtube.com/watch?v=uVu6w7Sb-vE

Upper Body Workout

Instructions, environment and movement characteristics can be viewed here:

https://www.youtube.com/watch?v=iE6tpzXbFJY

https://www.youtube.com/watch?v=uVu6w7Sb-vE

Xbox Kinect 360 + Kinect camera.

Exergames: "Your shape", "Kinect Adventures"

Publications using some/ all of these games: Bieryla 2016.

Instruction from publication: "The training and order of the games were the same for all participants to minimize variability. The first 15 min was composed of Your Shape: Fitness Evolved Zen Sessions (Stream 1 and 2)". "Participants followed an instructor on screen while completing a series of yoga and tai chi exercises".

Your Shape: Fitness evolved Zen Session

Instructions, environment and movement characteristics can be viewed here:

https://www.youtube.com/watch?v=WFtx3HhHlIQ

“The second 15 min was composed of games from Kinect adventures!, including 20,000 leaks, rally ball, and reflex ridge. Kinect adventures! was chosen due to the fun nature of the game while requiring participants to complete various movements that may help with balance. A specific level for each game was used. The specific level for 20,000 leaks was ‘‘Crab Crazy,’’ for rally ball was ‘‘Peek A Boo,’’ and for reflex ridge was ‘‘Collector.’’ Participants moved in the field of play (approximately 1.8 9 1.8 m), raised and lowered arms, and lowered their body position to complete tasks. The tasks included plugging holes in a virtual fish tank with their hands and feet (20,000 leaks), hitting a ball toward targets (rally ball), and avoiding obstacles while collecting coins (reflex ridge)”.

Kinect adventures

20,000 leaks – Crab Crazy

Instructions, environment and movement characteristics can be viewed here:

https://www.youtube.com/watch?v=mRz2aGDKPcg

Rally Ball – Peekaboo

Instructions, environment and movement characteristics can be viewed here:

https://www.youtube.com/watch?v=G2FGopLbPf0

Reflex Ridge - Collector

Instructions, environment and movement characteristics can be viewed here:

https://www.youtube.com/watch?v=DKSiZziset4

Nintendo Wii + Wii Balance Board + Mini Bike: “The Nintendo Wii consists of a console, a nun chuck and a balance board.”

Exergame: “Fit For All” – Hiking, Cycling (Stationary mini-bike), Ski Jump, Arkanoid, Apple Tree, Fishing, Mini-golf, weightlifting and resistance gaming exercises.

Publications using some/ all of these games: Konstantinidis et al., 2016.

Instruction from publication: “The FitForAll (FFA) platform consists of specifically designed games aiming at elderly exercise and maintenance/advancement of healthy physical status and wellbeing. FFA offers elderly-specific exercises within an engaging game environment aiming at promoting physical exercise protocol adherence. Through contemporary controllers (Nintendo Wii Remote Controller, Nintendo Wii Balance Board.” “The full game suite is composed of aerobic, strength, balance and flexibility computerized exercises blended with games. The following game types compose the game suite. In Hiking or Cycling (aerobic exercises) seniors are supposed to march on the spot or cycle on a stationary mini-bike; FFA makes use of an avatar moving through a city landscape to render exercise enjoyable. In Ski Jump (strength, flexibility) the senior is to move the center of mass to a specific position, thus controlling an avatar's jump performance (maximum length travelled). In the well-known Arkanoid (dynamic balance) seniors control the horizontal position of a bar and attempt hitting a moving ball (directed to destroy bricks). In another dynamic balance game, Apple Tree, seniors move to control a basket picking apples from a tree. Likewise, in Fishing (dynamic balance too) seniors control the vertical position of a boat which attempts fishing the horizontally moving fishes. In Mini-Golf seniors move their center of mass and attempt to put a ball into a hole by overcoming different barriers. Finally, numerous exercise tasks increase upper and lower limb strength by weightlifting and resistance gaming exercises, while stretching and warm-up exercises account for flexibility training. Senior feedback and overall reward is empowered by pictures of positive valence which are revealed gradually with increasing repetitions and upon completion in an effort to engage seniors.

Figure 177

"FitForAll indicative game interfaces and in-game feedback. A. Hiking: colored representation of action required. B. Ski Jump: user guidance. C. Arkanoid: game event message. D. Apple Tree: achievements panel. E. Fishing: motivating messages on low performance. F. Mini-Golf: red color indicates time end up".

Example gaming can be viewed here:

https://www.youtube.com/watch?v=IR-cEsuuOow

All YouTube videos for 6 additional publications were accessed on the 13/12/2017.

9.3 Appendix C

Published manuscript: Movements elicited by older adults during exergaming interventions that are associated with the Systems Framework for Postural Control: a systematic review

Robin Tahmosybayat[a], BSc, Katherine Baker[a], PhD, Alan Godfrey[b], PhD, Nick Caplan[a], PhD, Gill Barry[a], PhD.

a Department of Sport, Exercise and Rehabilitation, Faculty of Health and Life Science, University of Northumbria, Newcastle Upon Tyne, UK.

b Department of Computing and Information Science, Faculty of Engineering and Environment, University of Northumbria, Newcastle Upon Tyne, UK.

Corresponding Author
Gill Barry PhD, FHEA, MSc, BSc (Hons)
Senior Lecturer in Biomechanics
Department of Sport, Exercise and Rehabilitation
Faculty of Health and Life Sciences
Northumbria University
Newcastle upon Tyne
NE1 8ST

Abstract

One in three older adults fall annually in part due to impairments in the physiological systems that make up the postural control (PC) system. Exercise, particularly balance training, helps to prevent deterioration and even improve outcomes in the PC system. Exergaming is interactive computer gaming whereby an individual moves the body in response to onscreen cues in a playful format. Exergaming (exercise-gaming) is an alternative method to standard practice for improving PC outcomes, which has also shown to minimise the risk of falling. Research pertaining to exergaming has received attention, yet is still in its infancy. There could be benefit in exploring the movements trained with respect to a framework known for identifying underlying deficits in the PC system, the Systems Framework for Postural Control (SFPC). This may help target areas for improvement in balance training using exergames and shed light on the impact for fall prevention. The literature search was conducted across six databases (CINAHL, EMBASE, PubMed, ISI, SPORTdiscus and Science Direct) using a range of search terms and combinations relating to exergaming, balance, exercise, falls and elderly. Quality assessment was conducted using the PEDro Scale and a custom-made quality assessment tool. Movements were rated by two reviewers based on the 9 operational definitions of the SFPC. Eighteen publications were included in the analysis with a mean PEDro score of 5.6 (1.5). Overall, 4.99 (1.27) of the 9 operational definitions of the SFPC are being trained in exergaming interventions. Exergaming does encourage individuals to stand up (3), lean while standing (4), move upper limbs and turn heads (6) and dual-task while standing (9), to some extent move the body forwards, backwards and sideways (1), and coordinate movements (2) but hardly at all to kick, hop, jump or walk (7), force a postural reaction from a physical force to the individual (5) and does not mimic actual changes in sensory context (8). This is the first review, to our knowledge, that synthesises the literature on movements trained in exergaming interventions with respect to an established theoretical framework for PC. This review could provide useful for designing exergames with PC outcomes in mind, which could help target specific exergames for the multi-factorial training needs of balance deficits. Some elements of PC are too unsafe to be trained using exergames such as restricting sensory inputs or applying physical perturbations to an individual to elicit postural responses.

Key words: Exergaming, Postural Control, Elderly, Movement Characteristics, Systems Framework for Postural Control

1. **1.0 Introduction**

1.1 Background

Falling is a consequential aspect of aging, neurological or musculoskeletal disease [1-4]. Exercise is a well-established means to reduce the risk of falling in older adults by significantly improving the systems that constitute balance, muscle strength, flexibility and endurance [5, 6]. To maintain balance, the visual, vestibular and somatosensory systems cooperate to create postural and kinetic reactions to the immediate environment and over time these systems inevitably begin to decline [7]. Balance based training has shown to improve the multitude of systems that constitutes the postural control (PC) system, which when impaired can be a strong predictor of falls for older adults [8-10].

Exergaming (exercise-gaming) is showing to be as effective as alternative methods at improving PC outcomes in community dwelling individuals [11, 12]. Current methods employed include group-based classes based on fall prevention training programmes such as the Otago exercise program [13] and the Falls Management Exercise programme (FaME) [14], which include key components such as balance, muscle-strengthening, flexibility and endurance [15] and well as Tai Chi and functional floor activities that train coping skills for confidence. The plethora of outcome measures used in exergaming interventions each hold individual limitations in higher functioning older adults, improvement retention has not been assessed longitudinally and the heterogeneity of intervention characteristics make generalising outcomes problematic [16].

Movement characteristics of exergames have been previously explored and have focused on stepping exergames due to their natural occurrence during gait and their importance in the prevention of falls [17]. The system setup used for exergames heavily influences the movements performed and therefore the movements trained during a given intervention. Although previous research has explored the importance of movement quality for designing future exergames for fall prevention, there is a need to utilise a framework based on postural control to fully understand the gaps in training for the underlying mechanisms. Outcome measures have been previously explored in a scoping review which identified components of PC included in standardised balance measures based on the Systems Framework for Postural Control (SFPC) [18]. The SFPC was designed to detect underlying balance problems from a balance assessment tool "BESTest" developed and validated by Horak and colleagues [19].

The ability to maintain equilibrium and postural orientation is reportedly context specific and the underlying physiological risk factors for balance are multifactorial, similarly to risk factors for falls [20]. In any of the six components of the SFPC (Table 1), a constraint can come about from neurological, musculoskeletal or medicinal factors and subsequently increase the risk of falls and injuries from falls. Biomechanical limitations in the feet and the base of support (BoS) can affect the limits of stability due to reductions in size, strength, range and control of the feet or increases in pain. Inaccurate representation of the stability limits from the central nervous system (CNS) may result in postural instability in basal ganglia disorders such as Parkinson’s disease [20]. A tilted or inaccurate internal representation of visual or postural verticality can result in an incorrect automated alignment with respect to gravity, which in turn increases instability, such as in individuals with unilateral vestibular loss (tilted) or individuals with hemi-neglect due to stroke (inaccurate) [21]. Older adults at risk of falls have shown to use movement strategies to maintain postural stability more at the hip than at the ankle and have used stepping actions due to the lack of ability to exert angle torque at the ankle as a preliminary strategy [22]. There is also a lack of control of dynamics in older fallers in the form of larger than normal lateral excursions of the centre of mass (CoM) and more irregular foot placements. These limitations during gait or during postural transitions can lead to a trip, slip or fall depending on the context of the immediate external environment. Limitations in the ability to communicate sensory information in complex internal sensory environments can also put individuals at risk of falling in specific sensory contexts (stood in a well lit room with a solid floor versus stood in a field at night) [23]. Individuals with Alzheimer’s disease may prohibit the re-weighting of sensory dependence from the CNS even with a reliable peripheral sensory system [20]. Cognitive processing is required for simple PC strategies and increase with the complexity of the task with the addition of a secondary task [24]. Neurological impairments can influence the ability to control posture and perform a secondary task and can lead to falls due to the lack of cognitive processing capabilities [20]. The use of the SFPC to rate exergames may help target areas that are or are not being trained in exergaming interventions and may provide recommended games for specific components of the framework to subsequently tailor future training.

Using the SFPC, this review will explore movement characteristics that train the PC system during exergaming interventions. We hope to systematically address which movements are being trained and which system set-up best meets the components of the SFPC. This approach may inform design of exergames in the future by addressing the underlying mechanisms of PC. The movements elicited during exergaming interventions may be dependent on the exergaming apparatus used, games played and movements required to drive the exergame.

1.2 Objective

Therefore, this systematic review aims to evaluate the movements trained with the consoles used in exergaming interventions associated with the components of the SFPC.

2.0 Method

2.1 Study selection criteria, search strategy and quality assessment

The reporting of this systematic review was performed according to the PRISMA guidelines [25]. Full details of the inclusion and exclusion criteria and the search strategy are provided in an earlier paper reporting interventions effects according to primary, secondary and tertiary PC outcomes in exergaming interventions [16]. Succinctly, randomized control trials (RCTs) and non-randomized control trials (non-RCTs) that assessed and reported PC outcomes were included. Interventions were compared with traditional balance training modes and/or no exercise controls and included trials studied healthy community-dwelling older adults over 60 years who may or may not have fallen. Publications were all written in the English language from the UK, USA, the Netherlands, France, Malaysia, Hong Kong, Japan, Taiwan and South Korea. No publications were translated. Trials that studied individuals with balance impairments that prevented unassisted ambulation were excluded. Six electronic databases were searched for articles published between January 2000 and April 2016 using search terms related to exergaming, balance, exercise, falls and older adults for interventions based in clinical and community based settings. A further search was conducted to identify any additional publications from April 2016 to December 2017 as this review follows on from a previous systematic review. Additional publications were written in the English language from the USA, Singapore, Greece, Czech Republic and Brazil. None of the additional publications were translated. Title, abstract and full text screening were conducted by one reviewer (RT) and checked by another (GB). Reference lists of included trials were searched for additional publications.

2.2 Data extraction

Specific details pertaining to the interventions, populations, study methods and quality assessment from the original search exist in a previous publication and therefore was not repeatedly extracted. Search strategy, study characteristics and quality assessment for the additional publications from April 2016 to December 2017 were extracted. The extracted intervention features were as follows: exergame characteristics (console, game, scoring, difficulty/progression) movement characteristics elicited during exergame training based on the 9 operational definitions by [18].

Table 1: Components of postural control operational definitions adapted from Sibley et al. (2015)			
Six components of SFPC	**Operational Definitions**	**Does the game:**	
1. Biomechanical constraints: degrees of freedom, strength, limits of stability	1	Functional Stability	Test the ability to move the centre of mass as far as possible in the AP and ML directions within the base of support?

	2	Underlying Motor Systems	Test strength and coordination sufficiently through the physical activity of the game?
	3	Static Stability	Test the ability to maintain position of the centre of mass in unsupported stance when the base of the support does not change (May include wide stance, narrow, 1-legged stance, tandem, any standing condition)?
2. Orientation in space: perception of gravity, verticality	4	Verticality	Test the ability to orient appropriately with respect to gravity (e.g. evaluation of lean)?
3. Movement strategies: reactive, anticipatory, voluntary	5	Reactive Postural control	Test the ability to recover stability after an external perturbation to bring the centre of mass within the base of support through corrective movements (e.g. ankle, hip, and stepping strategies)?
	6	Anticipatory Postural Control	Test the ability to shift the centre of mass before a discrete voluntary movement (e.g. stepping-lifting leg, arm raise, head turn)?
4. Control of dynamics: gait, proactive	7	Dynamic Stability	Test the ability to exert ongoing control of centre of mass when the base of the support is changing (e.g. during gait and postural transitions)?
5. Sensory strategies: integration, reweighting	8	Sensory Integration	Test the ability to reweight sensory information (vision, vestibular, somatosensory)

			when input altered?
6. Cognitive processing: attention, learning	9	Cognitive influences	Test the ability to maintain stability while responding to commands during the task or attend to additional tasks (e.g. dual-tasking)?
AP = Anteroposterior, ML = Mediolateral			

2.3 Data Analysis

A rating scale was created based on nine operational definitions of the SFPC (Table 1). For each exergame and each component of the SFPC, movements were rated according to the following Likert scale: yes = 1, mostly = 0.75, somewhat = 0.5, less likely = 0.25 and no = 0. The movements required to drive each exergame were rated by two reviewers (RT and GB). GB is an expert in exergaming research and practice. In particular, exergaming to train postural control in older adults, sedentary and healthy populations, development of exergaming for Parkinson's disease. RT has experience in postural control interventions in an ageing population and the implementation of novel exergaming systems. Once all movements were individually rated for each individual exergame, the mean (SD) was calculated for each publication. The reviewers discussed movement ratings together based on inter-rater reliability and re-evaluated for alterations in judgements. If the exergames used were not stated in the publication, the authors were contacted. With no response, movements could not be rated or scored for that publication.

3.0 Results

Results of the initial search strategy, evidence level and quality assessment please refer to [16]. Results of the additional search strategy, evidence level and quality assessment can be found in supplementary file 1. All but one publication described the exergames used, whereby the author was contacted and failed to respond. Some, but not all exergames were described in that publication [26]. Table 2 presents the characteristics of equipment and exergames used in the interventions.

Table 2: Characteristics of equipment and games used in exergaming interventions					
Author and Date	**Systems and apparatus used**	**Games**	**Game Duration**	**No. of Levels/ game**	**Scoring Procedure / level**
Pluchino et al., 2012	Nintendo Wii Fit + Wii Balance Board	Soccer heading, ski slalom, ski jump, table tilt, tightrope walk, river bubble, penguin slide, snowboard slalom, lotus focus (Cool down game)	1st day: 7 minutes each, 2nd day: 5/8 games for 10 minutes each,	3 levels – Beginner, Professional & Expert	1-4 on each level
Ray et al., 2012	Nintendo Wii Sports and Fit, Wii Balance Board, Weighted Vest start at 2lbs and incremented 2 lbs / 2 weeks until 10lbs.	Wii Sports: Bowling + weighted Vest. Wii Boxing + weighted Vest. Wii Fit Plus games but no details of which games etc. Just stated balance and bodyweight shifting.	N/A	N/A	N/A
Toulotte et al., 2012	Nintendo Wii Fit + Wii Balance Board	Soccer heading, ski Jump, yoga, Ski Slalom, table tilt and tightrope walker.	G2: 1hr, G3: 30 minutes. Not stated how long per game.	3 levels - Beginner, Professional & Expert	1-4 on each level
Merriman et al., 2015	Laptop + Wii Balance Board used as interface device with Virtools 4.0 (Dassault Systems)	Custom Designed Games x 2. Apple Catch & Bubble Burst. Designed for older adults.	N/A	4 levels of difficulty	Apple Game: apple caught = 1 point,

					Bubble Pop: No. of bubbles popped per level
Sato et al., 2015	Microsoft Kinect	Apple game, tightrope standing, balloon popping, one-leg standing.	Apple Game, tight rope standing game: 90 secs. Balloon Popping Game: 40-90 secs.	Apple Game & Tight Rope: 3 levels of difficulty. Balloon popping game: 4 levels of difficulty.	N/A
Whyatt et al., 2015	Laptop + Wii Balance Board used as interface device with Virtools 4.0 (Dassault Systems), Zimmer frame for safety	Custom Designed Games x 4: Apple Catch, Bubble Pop, Avoid the Shark, and Smart Shrimp	N/A	4 levels of difficulty based on speed and position.	Continuous score throughout the games and were also presented with a final game score at the end of each level.
Lai et al., 2013	The Xavix Measured Step System ((XaviX port, one step mat)	N/A	N/A	N/A	Time standing, time exercising and total virtual distance travelled recorded

					during exercise.
Singh et al., 2013	Nintendo Wii Fit + Wii Balance Board	Ski Slalom, Table Tilt, Penguin Slide, Soccer Heading, Tight Rope Walk, Perfect 10 and Tilt City.	N/A	3 levels - Beginner, Professional & Expert	1-4 on each level
Chow and Mann, 2015	Xbox 360 Kinect	“Tiger Woods PGA Tour 13”	30-45 minutes/ game (10 holes/game)	10-hole gaming mode	N/A
Bieryla. 2016	Xbox 360 Kinect	Game 1: Your Shape-Fitness Evolved, Zen Sessions (Tai Chi and Yoga based exergame). Game 2: Kinect Adventures, 20,000 Leaks (Crab Crazy), Rally Ball (Peek A Boo) & Reflex Ridge (Collector)	15 minutes Game 1, 15 minutes Game 2.	N/A	N/A
Boon Chong & Yong Hao. 2016	Nintendo Wii + Wii Balance Board + Resistance bands	WiiActive (EA Sports Active): Run and Walk, Boxing, Inline skating, Biceps Curl, Triceps Kickbacks, Squats and Calf raise, Knee Crunch, Dancing, Shoulder Press, basketball, lunging, baseball, shoulder raises and tennis.	20 minutes per session	3 Levels for each individual game. Easy, Medium and Hard.	Number of repetitions/ goals or points scored.

Monteiro-Junior, R. S., et al. (2017)	Nintendo Wii controller + Wii balance board	Wii Fit Plus: Rowing Squat, Penguin Slide, Basic Run Plus. EA Sports Active: Bump and Set, Heavy Bag and Dance Basic 1 (Volleyball, Boxing & Dancing).	Performed each game once per session. 30 – 45 minutes per session.	Wii Fit Plus: 3 levels - Beginner, Professional & Expert. EA Sports Active: N/A	Wii Fit Plus: 1-4 on each level. EA Sports Active: N/A
Padala et al., 2017	Nintendo Wii + Wii balance board	Wii Fit: Half Moon, Torso Twist, Deep breathing, Ski slalom, penguin slide, tight rope walk, table tilt, balance bubble, Perfect 10	45 minutes	3 levels - Beginner, Professional & Expert	1-4 on each level
Konstantinidis et al., 2016	Fit For All: Nintendo Wii controller + Wii balance Board, Stationary mini-bike	Hiking, Cycling, Ski Jump, Arkanoid, Apple Tree, Fishing, Mini-golf, weightlifting and resistance gaming exercises	N/A	Each session has a difficulty level comprised of two components; intensity and gameplay difficulty. 4 levels from light exercise to intense physical exercise.	N/A
MaixnerovÁ, Svoboda, XaverovÁ, DupalovÁ, & Lehnert, 2017	Nintendo Wii Fit + Wii balance board	Penguin Slide, Table Tilt & Balance Bubble	Each game 5 minutes each	3 levels - Beginner, Professional & Expert	1-4 on each level

Nicholson et al., 2015	Nintendo Wii Fit + Wii balance board	Soccer heading, penguin slide, ski slalom, ski jump, table tilt, snowball fight, perfect 10, and tightrope walking	30 minutes	3 levels - Beginner, Professional & Expert	1-4 on each level
Park et al., 2015	Nintendo Wii Fit + Wii balance board	Soccer Heading, Snowboard Slalom, and Table Tilt	10 minutes on each game for a total of 30 minutes.	3 levels - Beginner, Professional & Expert	1-4 on each level
Tange et al., 2012	Nintendo Wii Fit + Wii balance board	Wii Fit, Wii Sports. Table Tilt is the only game mentioned	N/A	3 levels - Beginner, Professional & Expert	1-4 on each level
N/A = Not Applicable; G2 = group 2; G3 = group 3					

3.1 Consoles and Games

Of the eighteen publications, eleven used the Nintendo Wii™ with commercially available exergames (Wii Fit™, Wii Sports™ and/or EA Sports Active™) [26-36]. The most frequently used commercial exergame for the Wii Fit™ was "Table Tilt" used in eight publications, followed by; "Penguin Slide" in six publications. "Soccer Heading", "Ski Slalom" and "Tight Rope Walk" were all used in five publications. "Ski Jump" and "River Bubble" were used in three publications. Yoga based games on the Wii™ and "Perfect 10" were both used in two publications and the rest of the commercially available exergames were only used once in a given publication. Three publications utilised a custom design set up, whereby two used a Wii Balance Board™, a laptop computer with custom designed exergames for older adults and two exergames; "Apple Catch" and "Bubble Burst" [37, 38]. "Avoid the Shark" and "Smart Shrimp" were also used in one of the publications. Another publication used a custom designed platform called "Fit For All" which utilised a Wii Nun chuck™ and a Wii Balance Board™ among other equipment, to navigate web-based custom designed exergames; "Hiking", "Cycling (Stationary mini-bike)", "Ski Jump", "Arkanoid", "Apple Tree", "Fishing" and "Mini-golf" [39]. Three publications used a Microsoft Kinect™ camera, one with a custom designed set up with "Apple Game", "Tight Rope", "Balloon Pop" and "One Leg Standing" games [40], which seem to be closely related to the commercially available exergames of the Nintendo Wii Fit™. The other two Kinect™ based set ups used the Xbox 360 with commercially available exergames; "Tiger Woods" [41], "Your Shape: Fitness Evolved" and "Kinect Adventures" [42]. One publication utilised a Xavix Measured Step System (XMSS). The games available with the XMSS were; "Step Lively", "Vigorous Step", "Jackies Action Run", "Dash" and "Reflex". Information pertaining to exergames used in this publication was sourced elsewhere as no details of the games used were declared in the publication [43]. The publications utilising Wii Sports™ did not describe the games, duration, levels, scoring method or the movements necessary [26, 32].

3.3 Movement Characteristics

Of the eighteen publications, eleven described the movements, four from custom designed exergames [37-40] and seven from commercially available exergames [27, 31, 33-35, 42, 43]. It should be noted that some publications described the movements in more detail in the control group than in the exergaming group [26, 28, 29, 31]. "Weight shifting", "Side to side", "Medio-lateral", "anterior-posterior", "COP displacement" "arm raise" and "leg raise" were the most commonly used terms to describe the movements to perform the exergames whereby more detail was given in the custom designed exergames which included the reasoning behind movements to drive the game. For this reason, an additional document was created to describe the internal game environment for most exergames and where possible, movements required to drive each exergame and scoring method. Where this was not provided, a hyperlink to a YouTube™ video is provided. This can be found in supplementary file 2.

3.4 Exergaming movements evaluated using the SFPC

The overall mean (SD) movement rating score for the eighteen included publications was 4.99 ± 1.27 of a possible 9 points, which when expressed as a percentage is 55 ± 8%. The overall mean scores expressed as a percentage for each operational definition of the SFPC for included publications were as follows: static stability (92%), cognitive influences (dual tasking) (92%), verticality (90%) and anticipatory postural control (84%). Functional stability (57%) and underlying motor systems (55%) were trained in just over half of the exergames. The least trained aspects of the SFPC were dynamic stability (29%), reactive postural control (0%) and sensory integration (0%). Some publications that used commercial "off the shelf" consoles and exergames or a custom set up with commercial apparatus (Wii Balance Board™) restricted training mainly to static stability due to a static BoS and this was reflected in the score. This was also the case for a publication that used a custom designed exergame with a Kinect™ camera, whereby the nature of the movements to drive each game required only static BoS and reaching tasks. The highest scoring publication used the commercially available "Your Shape-Fitness Evolved" and "Kinect Adventures" exergame which used a Kinect™ camera set up [42]. With reference to the SFPC, this review has shown that exergaming does encourage individuals to stand up (3), lean while standing (4), move upper limbs and turn heads (6) and dual-task while standing (9), to some extent move the body forwards, backwards and sideways (1), and coordinate movements (2) but hardly at all to kick, hop, jump or walk (7) and does not force a postural reaction from a physical force to the individual (5) nor mimic actual changes in sensory context (8). Results for movement ratings relative to the SFPC can be observed in Table 3.

Table 3. Ratings for movements trained in Exergaming interventions relative to the Systems Framework for Postural Control

Operational Definition of the Systems Framework for Postural Control										
Publication	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total/ 9**
Pluchino et al., 2012 *										
Wii Fit -Soccer Heading	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**4.88**
Ski Slalom	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**4.88**
Ski Jump	0.50	0.63	1.00	1.00	0.00	0.00	0.00	0.00	1.00	**4.13**
Table Tilt	1.00	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**5.50**
Tightrope Walk	0.50	0.50	1.00	1.00	0.00	1.00	0.63	0.00	1.00	**5.63**
River Bubble	1.00	0.25	1.00	1.00	0.00	1.00	0.25	0.00	1.00	**5.50**
Penguine Slide	0.50	0.25	1.00	1.00	0.00	0.75	0.25	0.00	1.00	**4.75**
Snowboard Slalom	0.50	0.25	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**4.75**
Mean										**5.00**
SD										**0.51**
Ray et al., 2012 *, **										
Wii Sports - Bowling	0.00	0.13	1.00	0.63	0.00	0.00	0.13	0.00	0.63	**2.50**
Wii Sports - Boxing	0.25	0.38	1.00	0.63	0.00	0.75	0.13	0.00	0.75	**3.88**
Mean										**3.19**
SD										**0.97**
Toulotte et al., 2012 *										
Wii Fit -Soccer Heading	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**4.88**
Ski Slalom	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**4.88**
Ski Jump	0.50	0.63	1.00	1.00	0.00	0.00	0.00	0.00	1.00	**4.13**
Table Tilt	1.00	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**5.50**
Tightrope Walk	0.50	0.50	1.00	1.00	0.00	1.00	0.63	0.00	1.00	**5.63**
Yoga	1.00	0.88	1.00	0.75	0.00	0.00	0.50	0.00	1.00	**5.13**
Mean										**5.02**
SD										**0.54**
Merriman et al., 2015 ***										

Apple Catch	0.50	0.25	1.00	1.00	0.00	1.00	0.00	0.00	0.88	**4.63**	
Bubble Pop	1.00	0.38	1.00	1.00	0.00	1.00	0.38	0.00	0.88	**5.64**	
Mean										**5.13**	
SD										**0.71**	
Sato et al., 2015 ****											
Apple Game	0.50	0.25	1.00	1.00	0.00	1.00	0.13	0.00	0.88	**4.75**	
Tightrope Standing	1.00	0.25	1.00	1.00	0.00	1.00	0.25	0.00	0.88	**5.38**	
Balloon Popping	0.25	0.63	1.00	1.00	0.00	1.00	0.38	0.00	0.88	**5.14**	
One-leg Standing	0.25	0.75	1.00	0.88	0.00	1.00	0.38	0.00	1.00	**5.26**	
Mean										**5.13**	
SD										**0.27**	
Whyatt et al., 2015 ***											
Apple Catch	0.50	0.25	1.00	1.00	0.00	1.00	0.13	0.00	1.00	**4.88**	
Bubble Pop	1.00	0.38	1.00	1.00	0.00	1.00	0.25	0.00	1.00	**5.63**	
Avoid the shark	1.00	0.50	1.00	1.00	0.00	1.00	0.25	0.00	1.00	**5.75**	
Smart Shrimp	1.00	0.38	1.00	1.00	0.00	1.00	0.25	0.00	1.00	**5.63**	
Mean										**5.47**	
SD										**0.40**	
Lai et al., 2013 *****											
XMSS - Step Lively	0.63	0.75	1.00	1.00	0.00	1.00	0.75	0.00	1.00	**6.13**	
Vigoros Step	0.50	0.75	1.00	1.00	0.00	0.88	0.63	0.00	1.00	**5.76**	
Jackie's Action Run	1.00	1.00	1.00	1.00	0.00	1.00	0.88	0.00	1.00	**6.88**	
Dash	0.50	0.75	1.00	1.00	0.00	0.88	0.63	0.00	0.00	**4.76**	
Reflex	0.25	0.63	1.00	1.00	0.00	1.00	0.75	0.00	1.00	**5.63**	
Mean										**5.83**	
SD										**0.77**	
Singh et al., 2013 *											
Wii Fit -Soccer Heading	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**4.88**	
Ski Slalom	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**4.88**	
Table Tilt	1.00	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**5.50**	
Tightrope Walk	0.50	0.50	1.00	1.00	0.00	1.00	0.63	0.00	1.00	**5.63**	
Penguin Slide	0.50	0.38	1.00	1.00	0.00	1.00	0.25	0.00	1.00	**5.13**	
Perfect 10	0.75	0.38	1.00	1.00	0.00	1.00	0.25	0.00	1.00	**5.38**	
Tilt City	0.50	0.25	1.00	1.00	0.00	1.00	0.13	0.00	1.00	**4.88**	
Mean										**5.18**	
SD										**0.32**	

Chow and Mann, 2015 ****											
Tiger Woods PGA tour	0.25	0.38	1.00	1.00	0.00	0.50	0.13	0.00	0.50	**3.76**	
Mean										**3.76**	
SD										**N/A**	
Boon Chong & Yong Hao, 2016 *											
EA Sports Active - Heavy Bag	0.25	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**4.75**	
Targets and Heavy bag (Boxing)	0.25	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**4.75**	
Targets	0.25	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**4.75**	
WBB Targets and Heavy Bag	0.25	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**4.75**	
Dance	0.50	0.25	1.00	1.00	0.00	1.00	1.00	0.00	1.00	**5.75**	
WBB Dance	0.50	0.25	1.00	1.00	0.00	1.00	0.38	0.00	1.00	**5.13**	
Kickups	0.50	0.88	1.00	1.00	0.00	1.00	1.00	0.00	1.00	**6.38**	
Run, knees and kickups	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	**7.00**	
Run	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	**7.00**	
Upper body (resistance band) - Biceps curl	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	**1.50**	
Shoulder press	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	**1.50**	
Triceps Kickback	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	**1.50**	
Upright Row	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	**1.50**	
Bent over row	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	**1.50**	
Shoulder raise - Front	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	**1.50**	
Shoulder raise - Lateral	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	**1.50**	
Lower body - Alternating Lunges	0.88	1.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	**6.88**	
Alternating Side Lunges	0.63	1.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	**6.63**	
Knee crunch	0.63	0.88	1.00	1.00	0.00	1.00	1.00	0.00	1.00	**6.50**	
Squats	0.50	1.00	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**5.50**	
Squat holds	0.50	1.00	1.00	1.00	0.00	0.75	0.00	0.00	1.00	**5.25**	
Sports - Shooting and passing (Basketball)	0.25	0.25	1.00	1.00	0.00	1.00	0.50	0.00	1.00	**5.00**	
Inline Skating	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	**7.00**	
Backcourt (Tennis)	0.50	0.25	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**4.75**	
WBB Tennis	0.50	0.25	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**4.75**	
Pitching and Batting (Baseball)	0.50	0.25	1.00	1.00	0.00	1.00	1.00	0.00	1.00	**5.75**	

Mean										**4.57**	
SD										**2.05**	
Padala et al, 2017*											
Wii Fit - Ski Slalom	0.50	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**5.00**	
Table Tilt	1.00	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**5.50**	
Tightrope Walk	0.50	0.50	1.00	1.00	0.00	1.00	0.63	0.00	1.00	**5.63**	
Penguin Slide	0.50	0.38	1.00	1.00	0.00	1.00	0.25	0.00	1.00	**5.13**	
Perfect 10	0.75	0.38	1.00	1.00	0.00	1.00	0.25	0.00	1.00	**5.38**	
River Bubble	1.00	0.25	1.00	1.00	0.00	1.00	0.25	0.00	1.00	**5.50**	
Yoga	1.00	0.88	1.00	0.75	0.00	0.00	0.50	0.00	1.00	**5.13**	
Mean										**5.32**	
SD										**0.24**	
Bieryla, 2016****											
YourShape - Fitness Evolved - Zen Session	1.00	0.88	1.00	0.50	0.00	0.00	0.25	0.00	1.00	**4.63**	
Kinect Adventures - 20,000 Leaks	1.00	0.88	1.00	1.00	0.00	1.00	1.00	0.00	1.00	**6.88**	
Rally Ball	1.00	0.88	1.00	1.00	0.00	1.00	1.00	0.00	1.00	**6.88**	
Reflex Ridge	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	**7.00**	
Mean										**6.34**	
SD										**1.15**	
Monteiro-Junior et al, 2017*											
Wii Fit - Rowing Squats	0.38	1.00	1.00	1.00	0.00	1.00	0.00	0.00	0.50	**4.88**	
Basic run plus	0.50	1.00	1.00	1.00	0.00	1.00	0.50	0.00	1.00	**6.00**	
Penguin Slide	0.50	0.38	1.00	1.00	0.00	1.00	0.25	0.00	1.00	**5.13**	
EA Sports Active - Bump and Set (Volleyball)	0.50	0.75	1.00	1.00	0.00	1.00	0.50	0.00	1.00	**5.75**	
Heavy Bag (Boxing)	0.25	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**4.75**	
Dance	0.63	0.38	1.00	1.00	0.00	1.00	1.00	0.00	1.00	**6.00**	
Mean										**5.42**	
SD										**0.57**	
Nicholson et al., 2015 *											
Wii Fit -Soccer Heading	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**4.88**	
Ski Slalom	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**4.88**	
Ski Jump	0.50	0.50	1.00	1.00	0.00	0.00	0.00	0.00	1.00	**4.00**	
Table Tilt	1.00	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**5.50**	
Tightrope Walk	0.50	0.50	1.00	1.00	0.00	1.00	0.63	0.00	1.00	**5.63**	
Penguin Slide	0.50	0.38	1.00	1.00	0.00	1.00	0.25	0.00	1.00	**5.13**	

Perfect 10	0.75	0.38	1.00	1.00	0.00	1.00	0.25	0.00	1.00	**5.38**	
Snowball Fight	0.50	0.25	1.00	1.00	0.00	1.00	0.25	0.00	1.00	**5.00**	
Mean										**5.05**	
SD										**0.51**	
Park et al., 2015 *											
Wii Fit -Soccer Heading	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**4.88**	
Table Tilt	1.00	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**5.50**	
Snowboard Slalom	0.50	0.38	1.00	1.00	0.00	1.00	0.13	0.00	1.00	**5.01**	
Mean										**5.13**	
SD										**0.33**	
Konstantinidis et al., 2016***											
Fit for All - Hiking (Aerobic)	1.00	0.50	1.00	1.00	0.00	1.00	0.50	0.00	0.75	**5.75**	
Cycling (Seated Aerobic))	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.75	**1.25**	
Ski Jump	0.50	0.50	1.00	1.00	0.00	1.00	0.00	0.00	0.75	**4.75**	
Arkanoid	0.50	0.50	1.00	1.00	0.00	1.00	0.00	0.00	0.75	**4.75**	
Apple tree	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	0.75	**4.63**	
Fishing	0.50	0.38	1.00	1.00	0.00	1.00	0.00	0.00	0.75	**4.63**	
Mean										**4.29**	
SD										**1.55**	
Maixnerova et al. 2017*											
Wii Fit - Penguin Slide	0.50	0.38	1.00	1.00	0.00	1.00	0.25	0.00	1.00	**5.13**	
River Bubble	1.00	0.25	1.00	1.00	0.00	1.00	0.25	0.00	1.00	**5.50**	
Table Tilt	1.00	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**5.50**	
Mean										**5.38**	
SD										**0.21**	
Tange et al., 2012 *, **											
Wii Fit - Table Tilt	1.00	0.50	1.00	1.00	0.00	1.00	0.00	0.00	1.00	**5.50**	
Wii Sports - Boxing	0.25	0.38	1.00	0.63	0.00	0.75	0.13	0.00	0.75	**3.89**	
Mean										**4.70**	
SD										**1.14**	
Overall mean	**0.57**	**0.55**	**0.92**	**0.90**	**0.00**	**0.84**	**0.29**	**0.00**	**0.92**	4.99	
Overall SD	**0.31**	**0.26**	**0.27**	**0.28**	**0.00**	**0.35**	**0.35**	**0.00**	**0.18**	1.27	

*= Nintendo Wii + Balance Board + Wii Fit, **= Nintendo Wii + Wii Sports, ***= Laptop + Wii Balance Board, ****= Kinect, *****= other specialised technology.

4.0 Discussion

This systematic review aimed to evaluate the movements trained with the consoles used in exergaming interventions based on the components of the SFPC.

4.1 Main Findings

To our knowledge, this work represents the first attempt to synthesize the literature on movements trained in exergaming interventions with respect to an established theoretical framework for PC. The primary finding of this review is that of the included publications, no console and exergame setup trained all components of the SFPC. The consoles with a custom designed exergame or commercial exergames used "off the shelf" equipment. This makes it affordable yet not facilitative or tailored to the older individual which is well established [44]. The exergames used with the consoles were both commercially available and custom designed for older adults, yet still failed to train all components of the SFPC. Specifically, the perception of standing upright, reacting to a physical perturbation, control of dynamic balance such as postural transitions or dynamic balance during gait and essential sensory strategies to integrate or reweight information is not currently trained sufficiently no matter the set up or exergame used. These are all contributing components in multifactorial balance deficits and risk of falls [20]. Identifying postural-based training needs can help aid the specificity of targeted interventions which are contributing factor to effective fall reduction programmes [2].

The highest scoring set up was the Xbox 360™ and Kinect camera™ with exergames “Your Shape - Fitness Evolved” and “Kinect Adventures”, which are exergames that use whole body movements and stepping actions with various game components. It must be noted that the score was higher than that of other commercially available consoles due to the whole body movements and stepping actions required to drive the game. This contributed to forward and sideways leaning as well as the control of balance with a changing BoS, which are also integral components of a balance training programme that has previously shown a 35% reduction in falls and falls related injury [45]. The raised platform of the Wii™ failed to utilise stepping actions outside the BoS, thus only training static and dynamic balance within the limits of stability. Training the ability to stand up is important for conducting daily activities and is known to show increasing difficulty with age [46], but the likelihood of a fall increases once the BoS begins to change or when the limits of stability are compromised [20, 47]. Individuals incapable of walking unsupported for long periods may benefit from the nature of standing exergames to strengthen the supporting muscles whilst simultaneously utilising attention to perform postural transitions. This form of dual-tasking may prove useful in rehabilitation programmes for individuals not able to perform more complex dual tasks and may aid improvements in lower limb strength [48]. The “Tightrope Walk” exergame on the Wii™ did involve a changing BoS via alternating stepping actions on the raised platform, which was the highest scoring exergame for the Wii™. A Kinect™ camera set up used a commercial golfing game and another with a custom designed exergame. This setup is equipment free and permits more movement, yet does not always train dynamic balance outside the BoS. This setup is promising in its ability to utilise whole body movements without restriction to a platform, but the selected exergame used must encompass the necessary stepping movements in its design in order to target that component of PC. Step direction, size, length and speed all contribute to prevention of stumbling in everyday life alongside strengthening the lower limbs in older adults [49]. All publications in this review responded to additional tasks whilst trying to maintain and coordinate PC (dual-tasking). Exergames prove to be beneficial in this regard [50]. The magnitude of its benefit in conjunction with the SFPC remains unclear as the ability to differentiate the cognitive demand of each exergame was not explored in this review. It is known that that an increase in cognitive processing occurs with physical and cognitive task complexity [51]. Cognitive demands of exergames must be introduced slowly and sparingly for individuals with slower cognitive function [52].

All exergames trained the ability to orient appropriately with respect to gravity as all participants remained standing for all movements in all exergames. Individuals that suffer from a tilted perception of visual vertical such as those that have suffered a stroke or individuals with lesion of the “vestibular cortex” in the brain [21] may not benefit from this form of training as it unknown if changes occurred in their perception of vertical due to playing exergames.

Exergames, no matter the equipment used, did not train components of reactive PC. Reactive PC is initiated in response to an external perturbation (as low as within 100 milliseconds). The lack of a physical perturbation to an individual during gameplay means that corrective stepping actions are not strategically implemented. This fails to train the action of bringing the CoM back within the BoS once limits of stability are compromised, which is a fundamental mechanism of fall prevention [20]. Multi-directional stepping actions are the required response and guidelines that can prompt corrective movements such as stepping behaviour during exergames have been proposed [49]. Individuals that perform stepping actions during exergames are responding to on-screen cues and not physical perturbations, however, it can be argued that the motor control for the postural response is being trained via stepping actions [50]. Exergaming may help train the correct movement strategy selection and the magnitude of the response while responding to onscreen cues. Individuals have previously influenced postural responses with intention, expectation and experience [20]. The intention to play, expectations of the next movement required in the game and the general experience of playing exergames could have an effect on these responses.

Dynamic stability was component of PC minimally trained as there were no exergames that required a user to exert control of posture during gait, which would be impractical for the Kinect™ due to the spatial requirements within the range of the camera. Increasing dynamic contexts comes greater risk of falls and research has previously stated that balance training should be the primary focus in fall prevention programmes with walking as an additional component [5]. It is not physically possible to train dynamic stability with a changing BoS with the Wii™ balance board set up. Consoles that used a raised platform only trained this component within the BoS. The Kinect™ allows for more free movement than the Wii™, but the chosen exergames failed to consider movements outside the BoS in their design due to movements required to drive the game being static in nature. Some exergames did elicit postural transitions (steps, hops, skips) which do require the BoS to change from one posture to another. Fall prone individuals tend to have greater variability in moving from one posture to another which is typically when a fall can occur [20].

Another component of postural control not trained was sensory integration which involves integrating and reweighting information to other alternative sensory inputs when one input is disturbed (visual, vestibular or somatosensory). The importance of being able to re-weight sensory information from one sensory context to another is a key factor as falls can occur when there is a deficit in one of the senses (eyes, ears and body sensory feedback) [20]. It is not currently practical or safe to train PC via exergames in unsupervised environments that prohibit sensory inputs due to an increase in fall risk during training. However, with higher levels of cognitive task difficulty occurring during exergaming, there is higher domain resource competition in cognitive processing, which focuses attention on sensory integration [24] and it can be argued that by training at a higher level of cognitive function, attentional processes related to inhibitory control are engaged when sensory integration requirements are high [53].

4.2 Strengths and Weaknesses of the review

This review aimed to eliminate bias by following a strict protocol based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. There may have been a publication bias as mainly published articles were included in this review (all but one article) and as all articles were written in English, a language bias may have also been present. The population of focus in this review is limited to the healthier older adult over the age of 60 and cannot directly offer recommendations for those with disabling conditions and balance impairments. The movements rated in this review were based on movements described in the included publications and where movements were not described, an additional document was created whereby information on the movements and game environments were explored and documented by the lead researcher (RT). This was created by searching and observing web-based videos of individuals playing with the exergames and observing the movements during the games.

4.4 Implications for current best practice

Components of the SFPC should be considered when choosing apparatus and designing exergames for older adults and exergames that track movement compliance should be used, where possible, and rated during exergame training to monitor correct form and distinguish capabilities of older individuals. Future exergaming interventions should closely match movements in the exergaming group with that of the control group [54]. The movements should also be based on informed guidelines from current best practices and where possible incorporate movements that are theoretically linked to training deficits in PC. An exergame platform (Mira Rehab^{TM}) currently exists that considers older adults in its design and incorporates movements based on well-established balance training programmes [13, 55] with a strong cognitive element, that are tailored to the older adults interest, monitor progression and can be reviewed on a regular basis by a clinician via a digital platform of feedback. This exergame has been used for rehabilitation of balance outcomes in a pilot study with a small sample of participants [56] and in a recent research study exploring motivational determinants of older adults exergame participation in assisted living facilities to improve physical function and reduce fall risk [57]. Older adults appear to respond well to exergames through enjoyment and perceived improvement in physical and mental health [57].

5.0 Conclusions

A movement rating system is proposed in conjunction with an established theoretical framework. Not all elements of the framework are trained in exergaming interventions no matter the setup or the design of exergame. There are inherent limitations which remain a drawback of using this method to train postural control. Components of PC cannot be trained due to the unavailability of specialist equipment and spatial impracticalities that compromise safety of older adults. Other elements demand external physical input to test reactions of the PC system, which can't be accounted for in digital games. Exergames that elicit stepping actions and whole body movements outside the BoS better meet the requirements for training PC according to this framework. The design of exergames for the older adult must consider all trainable components of the SFPC in full by considering the full extent of the movement in each component.

Contributors

RT carried out the initial search and drafted the manuscript.

KB structured the review and helped draft the manuscript.

AG structured the review and helped draft the manuscript.

NC structured the review and helped draft the manuscript.

GB was the second reviewer to carry out the quality assessment and movement ratings on the relevant articles with RT, and helped to draft the manuscript.

All authors critically revised, read and approved the final manuscript.

Conflict of Interest

The authors declare that they have no conflict of interest.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Provenance and peer review

This article has undergone peer review.

Acknowledgements

This research is funded as part of a PhD programme within the Faculty of Health and Life Sciences at Northumbria University, Newcastle Upon Tyne, UK.

Appendix A. Supplementary Data Files

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9.4 Appendix D

COREQ (COnsolidated criteria for REporting Qualitative research) Checklist

A checklist of items that should be included in reports of qualitative research. You must report the page number in your manuscript where you consider each of the items listed in this checklist. If you have not included this information, either revise your manuscript accordingly before submitting or note N/A.

Topic	Item No.	Guide Questions/Description	Reported on Page No.
Domain 1: Research team and reflexivity			
Personal characteristics			
Interviewer/facilitator	1	Which author/s conducted the interview or focus group?	120-121
Credentials	2	What were the researcher's credentials? E.g. PhD, MD	120-121
Occupation	3	What was their occupation at the time of the study?	120-121
Gender	4	Was the researcher male or female?	120-121
Experience and training	5	What experience or training did the researcher have?	120-121
Relationship with participants			
Relationship established	6	Was a relationship established prior to study commencement?	121
Participant knowledge of the interviewer	7	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	121
Interviewer characteristics	8	What characteristics were reported about the inter viewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	121
Domain 2: Study design			
Theoretical framework			
Methodological orientation and Theory	9	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	125,128
Participant selection			
Sampling	10	How were participants selected? e.g. purposive, convenience, consecutive, snowball	121
Method of approach	11	How were participants approached? e.g. face-to-face, telephone, mail, email	121-122
Sample size	12	How many participants were in the study?	121
Non-participation	13	How many people refused to participate or dropped out? Reasons?	121-122
Setting			
Setting of data collection	14	Where was the data collected? e.g. home, clinic, workplace	122
Presence of non-participants	15	Was anyone else present besides the participants and researchers?	122
Description of sample	16	What are the important characteristics of the sample? e.g. demographic data, date	121-122, 125
Data collection			
Interview guide	17	Were questions, prompts, guides provided by the authors? Was it pilot tested?	125
Repeat interviews	18	Were repeat inter views carried out? If yes, how many?	125
Audio/visual recording	19	Did the research use audio or visual recording to collect the data?	125
Field notes	20	Were field notes made during and/or after the inter view or focus group?	125
Duration	21	What was the duration of the inter views or focus group?	125
Data saturation	22	Was data saturation discussed?	125
Transcripts returned	23	Were transcripts returned to participants for comment and/or	125

Topic	Item No.	Guide Questions/Description	Reported on Page No.
		correction?	
Domain 3: analysis and findings			
Data analysis			
Number of data coders	24	How many data coders coded the data?	128
Description of the coding tree	25	Did authors provide a description of the coding tree?	
Derivation of themes	26	Were themes identified in advance or derived from the data?	128
Software	27	What software, if applicable, was used to manage the data?	128
Participant checking	28	Did participants provide feedback on the findings?	128
Reporting			
Quotations presented	29	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g. participant number	128
Data and findings consistent	30	Was there consistency between the data presented and the findings?	128-129
Clarity of major themes	31	Were major themes clearly presented in the findings?	129-135
Clarity of minor themes	32	Is there a description of diverse cases or discussion of minor themes?	133-135

Developed from: Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*. 2007. Volume 19, Number 6: pp. 349 – 357

Once you have completed this checklist, please save a copy and upload it as part of your submission. DO NOT include this checklist as part of the main manuscript document. It must be uploaded as a separate file.

9.5 Appendix E

Ethics approval

MW

Mic Wilkinson <mic.wilkinson@northumbria.ac.uk>

Reply all |

Fri 10/06/2016, 14:24

arash.tahmosybayat

Inbox

You forwarded this message on 15/06/2016 09:20

Action Items

Hi Robin,

I am pleased to inform you that the project listed below has now been granted ethical approval. Please keep this message for your records.

Good luck with the study.

Mick

HLSRT060516

An investigation into the feasibility of exergaming as a means to improve postural control in an elderly population based in community settings.

Mick Wilkinson, PhD

Senior Lecturer

Sport, Exercise and Rehabilitation

Northumberland Building

Northumbria University

Newcastle-upon-Tyne

England

NE1 8ST

mic.wilkinson@northumbria.ac.uk

Tel: 0191 243 7097

micwilkinson.youcanbook.me

9.6 Appendix F

INFORMED CONSENT FORM

Project Title: An investigation into the feasibility of exergaming as a means to improve postural control, in an elderly population based in community settings.

Principal Investigator: Robin Tahmosybayat

I hereby confirm that I give consent for the following recordings to be made:

Recording	Purpose	Consent
Voice recording	To record thoughts and opinions of individuals within a group discussion based on different Exergaming modules for training balance.	

Clause A: I understand that no one else will hear the recording(s). The recordings will not be conveyed to me. My name or other personal information will never be associated with the recording(s).

Tick or initial the box to indicate your consent to Clause A ☐

Clause B: I understand that the transcript(s) may also be used for teaching/research purposes and may be presented to students/researchers in an educational/research context. My name or other personal information will never be associated with the recording(s).

Tick or initial the box to indicate your consent to Clause B ☐

Clause C: I understand that the full transcript and recording will be a confidential document. However, quotes from the transcript may be published in an appropriate journal/textbook or on an appropriate Northumbria University webpage. My name or other personal information will never be associated with the transcript(s). I understand that I have the right to withdraw consent at any time prior to publication, but that once the recording(s) are in the public domain there may be no opportunity for the effective withdrawal of consent.

Tick or initial the box to indicate your consent to Clause C ☐

please tick or initial where applicable

I have carefully read and understood the Participant Information Sheet.	☐
I have had an opportunity to ask questions and discuss this study and I have received satisfactory answers.	☐
I understand I am free to withdraw from the study at any time, without having to give a reason for withdrawing, and without prejudice.	☐
I agree to take part in this study.	☐

Signature of participant... Date....……………….. (NAME IN BLOCK LETTERS)...………………………
Signature of researcher... Date....……………….. (NAME IN BLOCK LETTERS)...………………………

9.7 Appendix G

Original UTAUT Questionnaire (Venkatesh et al., 2003)

Performance expectancy

U6: I would find the system useful in my job.

RA1: Using the system enables me to accomplish tasks more quickly.

RA5: Using the system increases my productivity.

OE7: If I use the system, I will increase my chances of getting a raise.

Effort expectancy

EOU3: My interaction with the system would be clear and understandable.

EOU5: It would be easy for me to become skilful at using the system.

EOU6: I would find the system easy to use.

EU4: Learning to operate the system is easy for me.

Attitude toward using technology

A1: Using the system is a bad/good idea.

AF1: The system makes work more interesting.

AF2: Working with the system is fun.

Affect1: I like working with the system.

Social influence

SN1: People who influence my behaviour think that I should use the system.

SN2: People who are important to me think that I should use the system.

SF2: The senior management of this business has been helpful in the use of the system.

SF4: In general, the organization has supported the use of the system.

Facilitating conditions

PBC2: I have the resources necessary to use the system.

PBC3: I have the knowledge necessary to use the system.

PBC5: The system is not compatible with other systems I use.

FC3: A specific person (or group) is available for assistance with system difficulties.

Self-efficacy

I could complete a job or task using the system…

SE1: If there was no one around to tell me what to do as I go.

SE4: If I could call someone for help if I got stuck.

SE6: If I had a lot of time to complete the job for which the software was provided.

SE7: If I had just the built-in help facility for assistance.

Anxiety

ANX1: I feel apprehensive about using the system.

ANX2: It scares me to think that I could lose a lot of information using the system by hitting the wrong key.

ANX3: I hesitate to use the system for fear of making mistakes I cannot correct.

ANX4: The system is somewhat intimidating to me.

Behavioural intention to use the system

BI1: I intend to use the system in the next <n> months.

BI2: I predict I would use the system in the next <n> months.

BI3: I plan to use the system in the next <n> months.

9.8 Appendix H

Focus Group 1

Interviewers: Interviewer - Gemma Wilson, Interviewer 2 /Transcriber - Robin Tahmosybayat.

Participants: (P1), (P2), (P3), (P4), (P5), (P6).

Interviewer: Brilliant, so it's really informal so please feel free to talk between yourselves as well, just one at a time for the recording, to make it easier for Robin to transcribe. Before we start could you just, ehh, first of all just say your name err out loud for us and try and speak up a little bit just because of the, err, the recording, ok? Ay? Just your first name

P1: Paula

P2: Kirsty

P3: Tom

P4: Ruth

P5: Richard

P6: Joanne

Interviewer: Lovely. Brilliant. So what were your thoughts on the games, first of all, did you? Did you know about exergaming before you came to this session?

P3: Yea, I've heard of it

P4: Yep

P5: Yea

P2: Yea

P6: Yea

P1: Yep, hmmf (Laugh)

Interviewer: Had any of you's heard of specifically the Wii or the Wii Fit and the Kinect as well?

P6: Played the Wii

P1: Heard about the Wii, not about the Kinect.

Interviewer: Did know about it but

P3: It's been out for a while now though hasn't it, the Kinect?

Interviewer: Yea it has

P2: Yea its sort of second generation.

P3: Yea its sort of like Christmas, four years ago, I swear.

P4: Yea I had the Wii for Christmas but I'd never played the Xbox one before

Interviewer: So most of you are better than…

P6: Never played the 360, no.

Interviewer: No

P3: I think the Wii's more widely known, isn't it? Everyone knows it.

P1: (Coughs)

Interviewer: Yea definitely, so most of you have heard about the Wii, but not so much about the Kinect.

P2: I've heard of the Kinect and I've played on both

Interviewer: Have you played on both?

P2: Not very often, it's one of those. It. It exists but we don't play on it like we play on the rest of computers.

Interviewer: Yea, so when would you tend to play on those type of?

P2: Christmas?

Interviewer: Yea

P2: When someone buys you a new game?

Interviewer: Yea

P1: Family events.

P4: Yea

Interviewer: Yea, um hmm

P1: If kids are around as well

Interviewer: Right.

P2: The problem is our house is not big enough, so you'll knock stuff off

Interviewer: Yea

P2: Like, in the lab it's fine you can jump around but in our house you'll break stuff

P1: Also just can't be bothered to get it out from wherever it is.

Interviewer: Yea

P3: Hmm

Interviewer: So practical limitations and more playing it as a group rather than by yourself.

P1: Yep definitely

Interviewer: Yea, and what did you think of both of the games? or what did you think of the Wii Fit to start?

P3: Seems a bit outdated,

Interviewer: Was it?

P3:After you played the Kinect

Interviewer: right

P3: I think it just seems bit, not very intuitive compared to what

P4: It looks like you're on the screen with the Kinect one, whereas the Wii it's just

P1: and the music's different as well

Interviewer: Right

P3: the music's different?

P4: Yea it is. It is.

P1: Hey, coz your like dancing on one (Kinect) and with like that one its like "dum dum" (Nintendo Wii).

Interviewer: It's a little bit slower and a bit.

P1: Yea

Interviewer: Yea

P1: But then I felt the instructions with that one (Nintendo Wii) were clearer than this one (Xbox Kinect)

P3: Yea

P4: Yea I did

P1: They gave like full page instructions, n' it was like well this one just says like bend your knees, lift your body up

Interviewer: Right

P1: So I think it's clearer on the Wii.

P6: I think you could get better at those games, you could, that would take you more time but I could, we got better at the jumps

P5: Yea

P6: and things like that and the tasks

P3: yea

P4: yea

P3: Coz lilly's really good

P6: Well ye she's

P4: Yea you're never going to beat lilly on the 360 are ye?

(General Laughter)

P3: Lillies really really good.

Interviewer: So that one was perhaps a bit more outdated

P1: Cough

Interviewer: More so the graphics and the music and yea

P3: Yea, pretty old school.

Interviewer: So did you enjoy playing the Kinect more than the … other one.

P2: That one was more fun

P3: Yea

P6: Yea I think so

P2: It was more energetic

Interviewer: Right

P2: and it felt like you were having more fun, that one is a bit more exercise, you feel like you're doing something it's asking you to do, and if you do it wrong it looks really upset at you and your like oh I've let the computer down oh no ha ha

Interviewer: hehe

P3: I think that one you always kind of think less because it is energetic, that's what I found anyway

Interviewer: uh huh, right

P3: but I don't really think much anyway so I don't know if that's part of it but.

Interviewer: Yea

P2: That ones more colourful and exciting

P3: Yea

P2: and flashing and oh its done now and this ones think about what you're doing,

P3: yea

Interviewer: Right, Yea

P2: Do it properly, try again

P1: But the only thing is that I was just having too much fun dancing. I wasn't really paying attention with that one, whereas with this one I was a lot more like aware of my body and what I've got to do to move it.

Interviewer: Right,

P1: ah haha

P3: Trying to sound

P6: but then you're static with that one, you can't move

P1: yea

P6: You’re stood on the board, and that’s the only place, so everything is, like, feet up movement if that makes sense.

P1: Yea, you can …

P6: Whereas with that, like, bombing around skating and doing all sorts of weird movements and things like that and that. You’re much more animated on that than you are there,

Interviewer: Right

P6: so no wonder that feels like exercise

P2: Well I think that the advantage of the Wii is you don’t see yourself and that some people are really self conscious. And when you can see yourself looking a bit silly and lost on the screen, like, ohhhf rabbit in headlights, whereas this one coz you can only see your mii, if you make your mii look like you but its not you, its always looks like its doing the right thing regardless of whether you are or not so if you’re feeling really self conscious this one might be better.

P6: Yea

Interviewer: So do you think you felt more self conscious because of the movement or just because

P2: Oh definitely more self conscious, I could see myself, definitely, I could see myself

Interviewer: Yea Yea

P4: I have to say I was concentrating on what my feet were trying to do than looking at myself on the TV.

Interviewer: Really

P4: I couldn’t have told you what I looked like all the time on the TV

P3: Looked stupid

P4: Well I’m sure it is but

Interviewer: ah ha

P4: but I was just concentrating more on what I actually had to do than looking at myself on the TV.

Interviewer: Why do you think you were concentrating more, was it because you were having fun? or because it was quite difficult or?

P4: because I know coordination isn’t my “forte”?

Interviewer: ah hahahaha

Everyone laughs

Interviewer: Excellent

P3: Yea I find that one like you say is a bit more immersive

P4: yea

P1: yea

Interviewer: Yea

P3: I don't think so much I just get on with it

Interviewer: Yea you just concentrate on what you're doing and getting through the game.

P4: That one was probably; well I thought that one was more competitive

Interviewer: Right, ah ha

P4: Than the Wii. Um because there's someone next to you when your doing it. Even though it is just like a cartoony type thing,

Interviewer: Right

P4: You could have someone else next to you and you could make it more competitive.

Interviewer: Yea

P4: which I preferred than the Mii

P3: I think that ones definitely group isn't it, and this would be better as an individual,

P4: Yea

P3 Thought we would be better individual at.

Interviewer: Right yea, and what about if you could have a friend with you, do you think you would prefer that if it was two people competing rather than it being a computer

General yea's

P3: yea, that would be much better.

Interviewer: yea

P2: and definitely the Xbox would be more fun, if you're playing as a group that ones much more fun

Interviewer: Definitely, excellent, so that one maybes, the Wii more for when you're playing individually and the Kinect when you're playing as part of a group.

General yea's from the whole group.

Interviewer: Absolutely, think about the movements and everything. What did you think of? Did you consider your balance and that you were training balance on either of the games?

P1: I would say balance more on the Wii, I was doing my balance and that one I was flying around the room left right and centre.

(Someone Coughs)

Interviewer: hehehehe

P1: Dancing. yea that ones really more focused on balance

Interviewer: Right

P1: what were you doing with your squatting? Was your squatting? good balance with your squatting?

P3: I think… no not really

Interviewer: hehehe

P3: I think on that one though its just again coz it’s a bit more immersive so I don’t really. I expect the exercises you’re doing on there require a lot more balance than actually the other exercises are

Interviewer: Right

P1: yea

P6: yea

P1: You’re not thinking about it as much

P3: but doing them you don’t really think about it but there (Wii Board) its tiny little movements so there you’re just jumping around which technically requires more balance skills.

P4: On the Wii you’ve got a board to fall off as well so you’ve got to be more aware of how you actually move rather than just like jumping around where you know you’ve got to, you can move but you’ve got to stay on the board at the end of the day otherwise you’re getting fired.

Interviewer: Right, so you’re more concentrating maybe on you’re movement as such on the Wii for not being able to move as much

P3: Yea

P4: Yea

Interviewer: Did you, did you think the same?

P5: I think that one was probably, as similar to what Tom was saying, I think that one probably is more technically difficult to do but you just don’t notice as much coz it’s almost you’re task dependent rather than performance dependent, that one feels more performance of what you’re being asked to do

Interviewer: Right

P5: whereas that one just feels more, bit more fun

Interviewer: Yea, so it’s the X360 you’re saying its more game you can have fun with it, that one will ask you to do something and you will do it.

P2: and its stops you if you are doing it wrong.

Interviewer: Right

P2: This one just goes “bluh” and it continues. That one goes nope start again. You’ve gone off before you’ve…

P5: As well, it’s really difficult to make that one get a good score on that one

Interviewer: Really?

P5: It always says poor performance or your balance is bad, which might not necessarily be a positive thing for someone that starts out doing something. Don’t want to be told you have got bad ‘discs’ when could just become removed from the sensation.

P6:Yea being…

Interviewer: Right

P6: Given one star out of five is a bit like …

P5: (Laughs)

P6: ok!? That's not good.

P3: Part from I did well, only missed thirteen of those slaloms

(General Laughter)

P6: Like…

P3: Shyea yea (laughing)

P2: And the thing is, it's really hard to know how do you get better? Like, on the Xbox you can see the character and you know what you could do because it's playing at a higher level than you are but on this one, how on earth do you get that first star?

P3: Yea

P2: Like how do you get a second star?

Interviewer: Right

P3: Don't know if you're doing good or bad do you?

P2: Yea it's really technically hard to make… the computers going nope nope and you're trying really hard and it's going nope nope nope nope.

Interviewer: And there's just no instructions, you don't know how to get better. Yea

P2: Whereas this one, you can just watch the person next to you, follow what they're doing and…and it doesn't stop you, it doesn't punish you for being bad it just goes nope you lost, try again. This one just makes you feel horrible, like, you're wrong, try again, stop, no and then the little mii goes "hmm" and looks really sad like oh, its bad.

Interviewer: Do you think you'd be motivated to change, motivated to try and get better at that one because of that or do you think its stops that motivation?

P2: No I think, I think you can't change it enough for it to go "well done, you've improved" It just always looks a bit depressed.

Interviewer: Right

P2: So you go oh well why play

P1: I kind of disagree a bit. I find that I would adjust myself more to that. Like I fell off restarted again and got to the end of the rope second time

Interviewer: Right

P1: So I… just to put it out there

P3: You did! Yea you did

P5: Didn't do that bad did you? (Laughs)

P1: Um, so not a big deal or anything

(General Laughs)

P3: Just to bring that up

P1: Um but no but I fell off just there whereas with that one I could just keep doing it but I'm just doing it to have fun not to focus on the technique or the balance or anything

Interviewer: Right, yea

P1: Like you said I could obviously whatever, like be because of the task itself could be doing more balance but I find with that I'm focusing a lot more because there is a board for me to stay on.

Interviewer: Right

P1: With that one I just fly around like an absolute idiot

P6: It depends

P2: Unfortunately no one else did (Laughs)

P6: I was just going to say it depends how easy it is to get the Wii fit character to change his emotion. You know, like, when you had a good experience there where you got to the end of the ropes, It was all bing bing bing bing but if it takes you ages, whats the likelihood of you giving up in that period of time? You know, like if it takes you ten goes to get…to get that second star.

P1: Well that will be… will really depend on each person

P6: Well that's what I mean, so if you kind of, you can you can progress easily and it works you can continue motivation wise but obviously it take a lot and it might vary on each different game on the Wii.

Interviewer: Where as, am I right in thinking that you's thought maybe more the motivation on that was the fun? That you were having fun

P6: yea

Interviewer: Rather than trying to progress and get better at it

(Coughs)

P2: It did tell you that you got a high score, so that was, you are still being scored

Interviewer: Yea

P2: And but because you go up by one point or two points or a thousand points you could see that if you had or knew what the last number was, you can still see yourself especially if you're only competing against yourself so you set your own high score.

Interviewer: Yea

P2: You'll see yourself go up but it's not going to punish you as bad

Interviewer: Right

P2: as… the… the Wii.

P1: One thing is that one's more full body. With that one I was only really using my lower limbs. When I was with… Well I mean they were here but they weren't doing a lot but with that one each time you've got to move your arms up and down to the sides, swing your arms so it's a lot more full body.

Interviewer: Yea, I know you have probably touched on it but did you? What? How complicated did you think they were to work? You know to use the controls and get into each game? Was one easier than the other and?

P3: It's a little bit easier I think (Wii) but that just might be coz I've played that a few times more often than I've played this.

Interviewer: Right Yea

P6: Yea I felt familiar with the Wii so it was easier to use.

P2: See I was better with that one but only coz we have an Xbox at home and play other games on it. We don't do the exergame or the exergaming but we have a Wii "U' and its "A"(?) alright to us or it's kind of its a standard response.

Interviewer: So Maybe's it depends on how somebody

P2: Well with that one you have to be able to point the Wii at the screen so if you're a bit shaky or if it goes "Wiiii" then you've gone off the screen again and you've got to get the pointer back again.

P4: You can use the erm cross thing as well. Yea you don't have to. Yea you can point it.

P6: No see I was pointing at going "Wiiiii" missed again "Wiiiii" missed again (Laughs)

P4: Yea, but then you can use the arrow.

P1: But that's too sensitive, with the action of that key jockey I kept missing it. I think when we were doing it… it was only… it was going up and down

P4: yea up and down

P1: Not that that would stop me playing it.

Interviewer: I was … that was… I was just going to say would it stop you playing it?

(General Laughter)

P1: Noooo

P3: Get used to it

P1: But yea you'd pick it up as you went along, hmm how sensitive it is.

P6: I thought that one was quite visually busy

P1: Yea

P4: Yea

P6: Like I know we were kind of slating the graphics on that one but there was a lot going on in that screen.

(General yea's in response)

P4: The Wii was a lot simpler

P6: Yea

P4: to look at

P6: There was your score up here, there was something else going on down there.

P4: There was something going on in the background.

P6: You were there, she was over here and it was like what? There was just a lot of things going on

Interviewer: Yea

P4: Yea

P6: I think it would take a little bit of time to get used to all things that were going on

P4: Yea

P6: and what they meant if you were new to

P2: It certainly helped having someone tell you the colour of the melons that you have to catch.

(General Laughs)

P4: Yea

P6: Yea I think that was Gill (Whispers)

(General laughs)

Interviewer: Is there anything you would change to either of the games to make them more engaging.

P2: I think

P3: Better music

P2: Yea

Interviewer: Better music?

P3: Better music

Interviewer: Yea

P2: I think, especially if you start from the beginning, the Mii should tell you if you advance for that one

Interviewer: Right

P2: So instead of going that was bad have one star, it should say you improved

P3: hmm?

P4: I think if you create your own Mii

P2: Yes

P4: from what I remember from the Wii, if you create your own Mii and then you're using your own Mii it does tell you if you've beat your high score

Interviewer: Right

P4: but I think you've got to create individual ones to do that. Not just use the generic one I think.

Interviewer: That's right yea yea, which would add more competitiveness as well

P4: Yea

Interviewer: mm hmm Did you feel, like I've said again we have talked a little bit about it, self conscious do… using these games today?

P2: I didn't like seeing myself on the screen

Interviewer: Yea

P2: But then I don't like seeing myself anyway so, whether it's a mirror or on a screen it doesn't matter

Interviewer: Yea

P2: I don't like being able to see myself, I'd rather watch a Mii of me doing it (Nervous Laughter)

P1: I liked it I thought it was fun

Interviewer: Did you?

P1: I certainly don't like staring at myself but yea it was fun

(Laughter)

Interviewer: So you specifically like

P1: Yea I liked it that when I was watching like Jo or Richie they were playing against Ruth without Ruth knowing as well (Laughter)

Interviewer: Yea

P1: Which means yes there were different people playing but I can see why for some people it can be uncomfortable to stare at yourself, yep.

P4: I don't think I felt self-conscious with myself on the screen because I didn't even look at that. The fact that I was prancing around a room pretending to be on a surfboard when I was flat on the ground, that would make me feel far more self-conscious than seeing myself on a screen.

Interviewer: Yea

P6: They're very false movements I think

P4: Yea

P6: Either of them are very like, you would perform those movements in a sequence of movements rather than in a physical activity rather than… so I think it always feels a bit disjointed whenever I play something like that, like exergaming, I think that you feel disjointed because that's not…

P4: what you'd normally do

P6: the movement you would normally do.

Interviewer: Yea

Interviewer: mmm hmmm

P6: If that makes sense

P4: Yea

Interviewer: mmm hmmm

P6: It would be a… it's a discreet movement

P4: I think some of those games on the Xbox though felt more like an exercise class that you have in the gym. Like that melon smashing one

(General Yea's)

P4: You'd do that if you were in a gym class so I suppose if you'd been to something like that before you'd be more comfortable with it rather than if you hadn't ever done anything like zumba or aerobics or something like that you wouldn't be as comfortable with it as you would…

P1: Then it was funny with the squatting one coz tom did the right technique the first time and then it told him to go lower and basically just rubbing his bum on the floor.

P4: But that's because I was in the way there (Laughs)

P1: Oh really (Laughs)

P4: That. That wasn't his fault because I was in the way and then I must have moved and Tom was …

P3: Thanks for that

P4: Sorry Tom

P1: (Laughing)

(General Laughing)

Interviewer: Did anyone find it less self-conscious on the Wii compared to the…maybe not?

P3: Didn't really think about it

P4: No I didn't

P6: I think you feel less like you're doing crazy movements

P4: Yea

P6: Like when I was doing the skating one I think you feel a bit more…

P2: You're a lot more static aren't you so theres less risk of you doing something that looks crazy on the wii because you're basically just staying on the board. Because on the Xbox you can dance around and you've almost got free movement haven't you

P1: But then I would be really weary because my mums just had a hip replacement and I wouldn't want her be doing and I don't think she would, whereas that one would be a lot better for her which is why shes got the Wii and shes actually got that

Interviewer: Really?

P1: So she wouldn't do that and neither would two of my family friends who are a lot older just coz of their lack of movement they wouldn't do that as much just kind of

P4: I think as well, like, if you were at home and there was other people in, and you just wanted to have half an hour, the Wii's far more… better for that coz everyone else can get on with what they're doing and you're not disturbing them. Whereas…

P1: (Laughs)

P4: If you were at home with all your family and you thought

P1: Surfing in the middle of the room

P4: I need to do ten minutes of balance practice or whatever, you couldn't switch on the Xbox because then everyone else would be involved and you wouldn't get what you wanted to do done, whereas the Wii you could just crack on with it, have ten minutes and leave it and it doesn't really involve anyone else as such if you don't want it too.

Interviewer: A bit more practical a bit more training

P4: Yea

Interviewer: like than playing the games on the Kinect

P4: Yea

Interview: what about if it was all strangers that you were playing. You all know each other and how would you have felt if there was two other people in your group that you didn't know at all. Would you be any more self-conscious do you think? Or…

P4: I would

P3: Pretty

P6: Yea I think so

P1: I wouldn't but that's just me.

(General Laughter)

Interviewer: Yea

P5: I think once you'd all played the game once

P4: Yea

P5: and you'd all performed at a similar level. You'd sort of lose that in five to ten minutes possibly

P4: Yea I agree

Interviewer 2: Like an Ice breaker

P5: Yea

Interviewer: Yea

P6: I think probably were all equally as good at…at I.T or using the systems if that… we could figure it out whereas if you had a group of three and like say I was poorer at I.T

P1: Hmmmm so somebody longer than the other one yea

P6: And like Richie had to help me all the time to get on to my next game

P1: Yea

P6: That would be a bit… I would, and then I wasn't very good at the exercises then I would feel even worse.

(General Yea's)

P2: Well if you had someone who was getting all really high scores and you couldn't beat them. That would make you feel quite bad as well. Like here it doesn't really matter coz we can laugh with each other but if you didn't know you could laugh with that person or without you being laughed back from someone you didn't know, that could make you feel quite demoralised.

(General Yea's)

Interviewer: So perhaps ability's important in terms of using the computer as well as using the games itself. Ummm hmmm. And what about your thoughts on the safety of using the... Did you feel unsafe at all when you were using the… the consoles or when you were doing the movements?

P2: If you're in a smaller room, it would have been much… You would have to be much more body aware using that one flying with your hands going around coz in case you knocked something off or…

Interviewer: Right

P2: Whereas, the Wii kind of keeps yourself within, although you can fall off the balance board at least you know you're in that area.

P4: Yea and it's not that big a fall really is it, if you do trip off it

Interviewer: Yea

P4: An inch (Laughs)

P2: I think we are in more danger of bouncing and actually lifting up from jumping rather than falling off

P4: Oh yea

Interviewer: and what about your thoughts on anxiety and exergaming as well in terms of, when you actually were you anxious about anything when you were… when you were playing the game, without falling or self-consciousness or … or were you just thinking about the game and…

P2: Just the game I think for me

P6: Yea just the game

P3: Yea just the game

P4: I think I was probably more anxious before it rather than doing it just because I didn't… like with the Wii I knew what to expect whereas the Xbox didn't know what to expect so that's probably the only bit of anxiety

P1: It helps that we saw somebody go before us

P4: Yea like Yea like Tom went before both me and Paula on that

Interviewer: Right

P4: so we got to see how he did it

P1: We got to see yea

P3: How badly I did ay?

P4: Yea

(General Laughs)

P6: And then we probably did the same

P4: But not

P1: And then you probably saw them doing it… yea

P6: Us three were all with the Wii beforehand, so we were having a little look at what you guys were doing, like oooh that game looks good and we will give that one a go and stuff so…

P1: Yea

Interviewer: So familiarisation and knowing what your expecting and that were unexpected

P4: Yea

P3: Yea

Interviewer: Definitely, and would you use either of the consoles again and either of the games again? And which ones and why?

P3: I wouldn't really just because I'm not that really into games

P1: I'm not either though… yea my family go outside

P3: I just wouldn't… I just never really would do it to be honest…

Interviewer: Right

P3: it's just not my thing

Interviewer: Yea

P1: I agree with Tom

Interviewer: Right

P1: But that's just our opinion

Interviewer: Yea

P2: See, we are a gaming family so it wouldn't be unusual for us to have the game. But we wouldn't choose to play this if we were going to do this kind of thing we would go outside and do it.

Interviewer: Right

P2: And then when we play on the console we were playing a console game, strangling game or a shooting game or we're actually playing a game that's usually static.

Interviewer: Right

P2: Errm, in our living room you couldn't… if even if you wanted to… you couldn't… if there's no room in there to… dance around and do things.

Interviewer: Right

We have both consoles at home but…

Interviewer: mm hmm

P2: You can't use them…

Interviewer: Right

P2: Because there's no room to use them.

Interviewer: Right, so practical issues and just personal interest in

P2: And and uh like I think Jo said if or if you want to sit and do something if one person for example wants to sit and watch the tele you cant then dance around in front of the Xbox

Interviewer: yea

P2: whereas you could have the balance board out and have the sound off doing just the exercise in front of it and the other person could watch the tele that's not a problem but you couldn't both use the living room with one of you dancing round like a lunatic.

Interviewer: Yea yea so depends what if there's other people around and what they want to do as well.

P6: My elderly neighbours would not appreciate me bouncing up and down on the Xbox Kinect on the first floor of a flat

(General Laughs)

P2: But…

P3: Yea but really they can't hear anything, that's fine

(General laughter)

P2: On the Brightside though…

P6: Although the old ladies are quite spritely downstairs

(General Laughter)

P2: On the Brightside though if you haven't set up you could just leave the Kinect out you wouldn't have to put it away. Because there's nothing for you to trip over. Whereas whenever you get the Wii out you have to pick the board up put the board away again afterwards. You cant just leave it out in the middle of the floor so I suppose it depends on who else is in your house and how much where you have got to store things.

P4: Just going back to old people as well like I know a lot of old people that don't go out and I think but when they were younger were very active and I think if the people like that if they felt competent in using it and they knew that there was benefits of using it and they had the

TV and what have you that it could be all set up and working and they had the space and it was safe to do so,

Interviewer: yea

P4: I don't see why they wouldn't want to do it if they knew it benefitted them they could do it in their own home and they knew how to do it and everything I don't see why they wouldn't do it or at least give it a shot anyway

Interviewer: mm hmm absolutely

P4: But I think for younger people like us we have a lot more options open to us and you've probably got a bit of a biased group that we al doing sport and exercise related stuff so we probabaly would all choose to go out and exercise in different ways.

P1: I'd go to the gym

P3: hmm

P4: Yea

Interviewer: So if you were specifically wanting to balance train you would, you wouldn't look at these, you would look at the gym or look at other outdoor activities. What about just playing them for fun? Would you …

P4: We got the Wii out at Christmas and after a few drinks and all played it and had a good laugh.

P6: Yea I've played the Wii with friends like got together and had like a meal or something and played Wii after and stuff so

P4: Yea

Interviewer: mm hm so again as a group more so than by yourself

P4: Yea I don't think I'd ever get the Wii out and sit there and do it by myself

Interviewer: Yea

P6: I had a go at the yoga function on the Wii just more because when I moved in with my other half he brought, he had the Wii and brought it with him and I was like oh like so we ended up playing on it and he liked playing bowling on it, he's a big kid but

P4: I used to like tennis

(General Yea's)

P4: tennis and bowling

P6: But we wouldn't do it now I think because its so old, because its so obsolete and we don't have the time and we go out and exercise so.

Interviewer: Yea

P2: I think if you're looking for older adults, my mum would probably play on the Wii…

Interviewer: Right

P2: But she probably wouldn't play on the Kinect

P1: mm

Interviewer: Right

P2: She'd be worrying about it watching her. So…

Interviewer: Right

P2: she's…

P1: Yea there's so much going on as well.

P2: Yea especially if you had it set up. You know you can set the Kinect up so it has voice command so you can say on or off or

Interviewer: Oh right

P2: Um yea she'd be absolutely paranoid. She'd be worried that someone was watching us but she would probably sit and play on the Wii and if you said that here's a programme for you coz she does like brain training and stuff so if you said here's physical training on the computer, she'd love that but it would be the Wii she'd go for.

Interviewer: Yea

P4: I think if there was a more… like a simpler game for the Xbox that didn't have the flashy backgrounds but still had the same sort of games on maybe not even such flashy games but like music games where you've got to step and stuff like that I think older people would go for that but I think with all the flashy backgrounds you can just imagine and they probably not got the best eye sights either if their older you can just imagine them being confused by it and scared.

Interview: Is there anything else you want to mention?

P6: I'm just going to say the Wii erm controller thing is more like a remote, like a tele remote they'll probably be familiar with whereas that's an actually erm… oh… like console controller thing isn't it and I think kind of that

Interviewer: Yea

P5: Can you only exercise one person at a time with a Kinect? Or can you have two?

P3: Na you can do two

P5: you can do two

Interviewer 2: I think you can yea multiplayer

P3: Can do two yea just split screen, seen that

(General Laughs)

P4: Pro

Interviewer 2: So you know your games really don't you

P3: Down with the kids

(General Laughs)

Interviewer: Something else you want to ask or? …

Interviewer 2: Umm no. No that's it

Interviewer: Brilliant. Thankyou very much

Interviewer 2: Cheers guys.

(General Thanks)

P3: You're Welcome

Focus Group 2

Interviewers: Interviewer – Robin Tahmosybayat Transcriber - Robin Tahmosybayat.

Participants: (P1), (P2)

Interviewer: So if you could just start off by telling me your first name, please?

P1: My name's Susan

P2: My name is Sedik

Interviewer: Ok, hello. Um so first of all um what were your thoughts on the games? Did you like them? Did you think…

P1: The Nintendo Wii

Interviewer: Yep

P1: Erm just seems a lot more… more slow.

Interviewer: mm Hmm

P1: Not in sync with… with you.

Interviewer: Right

P1: The person, whereas the Xbox just seems more technologically advanced so it's able to pick your body movement and pick you up

Interviewer: Right Yea

P1: Much more accurately

Interviewer: Ok, um, did you know like about, obviously the consoles before you came to this session?

P2: For me no.

Interviewer: No.

P2: But uh, I found it more accurate with the Xbox as she uh she said, uh giving more flexibility for the body

Interviewer: Right

P2: To how to balance how to perform the exercise more accurate you know.

Interviewer: Ok. Ok erm … and any particular game that you thought you favoured the most? On either of the consoles. If you say the console first and then the game. Not if. Just reference to one of the movements in the game if you like

P1: I think on the Xbox, the last game that I did. Uh. Aerobic one what was that again?

Interviewer: Yep. Erm I think it was the. Was that the one on the piano?

P1: Yep.

Interviewer: Yep

P1: Not the piano. The. On the. The surf and the

Interviewer: Oh yea. The waterfall jump. Ah right

P1: Yea the waterfall jump. Well that was really good it was aerobic so if you did have a spare ten minutes

Interviewer: It'd be good to do

P1: Yea just to kind of keep.

Interviewer: um hm

P1: Keep ye hap. You know keep fit. Keeping fit. I don't. I don't know how much kind of benefit it has but

Interviewer: mm

P1: but … yea. But it's better than the Nintendo Wii

Interviewer: Right.

P1: and

P2: For me I think it is uh the fruit splash

Interviewer: The fruit Splash one yea

P2: Yea. Just its more interesting how to err reach the fruits which is giving more flexibility for muscle endurance

Interviewer: Mmm hmm

P2: so this is. Will get the stability for the back and stuff. You know so

Interviewer: ok

P2: Which is just from my experience I don't know from the others.

Interviewer: Um so which, which games do you think would be, in terms of if I was to zone in on balance in particular, um do you have like a preference of console like the Xbox or the Nintendo and maybe which which game you think might have been more optimal for, um training balance or just generally exergaming in general, like in terms of training balance

P1: I think I would favour the Xbox. The Nintendo Wii just doesn't seem to accurately pick up the movement

Interviewer: Right ok yea

P1: Um the Kinect, I think, you know, although it was very active, you have to balance within that as well

Interviewer: yea

P1: The piano exercise was quite good, you know

Interviewer: mm hmm so it was like stepping and stuff

P1: Yea focus on… on you know, more being upright and not falling over basically.

(General Laughs)

Interviewer: Yea ok that makes sense, yea.

P2: For me I think it just eh, the board here balance it when you passing the… they can go here. You try to cross the… the line

Interveiwer: Oh the tight rope. The tightrope one yes

P2: Yes. It is more for the balancing.

Interviewer: Yes

P2: You know. Which is similar to gait balance.

Interviewer: Yea

P2: You could use it for peoples. Uh. Who they need. Uh such that disorders. So this one is. If you got to modified it, or do something to use it as good exercise for to balance

Interviewer: Ok

P2: Which is uh people some conditions need to be get the balances through the gait. I found this one is more interesting for them.

Interviewer: More related to that. Ok.

P2: It's not for the healthy you know so it's different.

Interviewer: Yea.

P2: So if you got it used for people who is with any conditions like back pain or any other unbalanced so this one is more… (exhales)… more benefit…beneficials and also the Xbox there is uh another game which is uh when you try to step, step by step, over the, to catch the, do you know?

Interviewer: Umm. The waterfall jump one? Where you had to step on the wood?

P1: On the boards

P2: Yep

Interviewer: on the boards and the surfing one. Yea that one Yea

P2: Yep. Yep That's it. This one is because uhhhh in physio there is a board. You would stand on it and do it as the same you know with the gait. So its uhh similar to that. I think people who is uh in this kind of trying you they could use this kind of game and um they can match them together you know

Interviewer: Right

P2: To see how its going, how its work, which is the best for people you know

Interviewer: To use like a bit of both so…

P2: Yep you could uh to be honest it is depends about people because when you are assessing people you will know which one match better for this one or this one. So you could go for this one because its easy for them.

Interviewer: the Nintendo

P2: Yea. And then you go for that so… its just different.

Interviewer: and so obviously there's different aspects of training balance and I suppose I'm, I'd like to gain a bit of insight into um so theres static and theres dynamic aspects of balance. So static, which is you know your more on the spot, your more at rest and then theres the dynamic as while you're moving

P1: uh huh

P2: uh huh

Interviewer: and if I could just give you those thoughts and just maybe think about which one maybe favoured static and which one maybe favoured dynamic or if they both did both in your opinion. Or? Do you have any thoughts on that?

P1: Yea. Definitely the Xbox is more dynamic

Interviewer: Yes.

P1: And the Nintendo Wii is more static.

Interviewer: Static yea.

P1: Erm and the fact that you have to stand on the… the... Wii Board.

P2: The board

P1: The Wii Board

Interviewer: Yea

P1: Then you know, that makes you kind of constrained to that… that area doesn't it

Interviewer: um hmm

P1: So you have to kind of

Interviewer: Yea and it doesn't let you jump either. So yea so obviously the Nintendo Wii doesn't let you jump as much does it?

P1: No. Yea you can't jump can you.

Interviewer: No

P1: That's the only thing with that. That's a little bit unrealistic because you can't jump and that's something

P2: The Xbox more yea. Uh huh, uh huh. Much more much more freedom. To jump and to.

P1: Yea

P2: Free movement with the other than that one because this one is more strict with the board so

Interviewer: Yea

P2: As I said which is depends about which people whos you are going to work with

Interviewer: Um hmm

P1: Yea

P2: So if you are going to work with the limitations for the people you could use this (Wii) and if its others so use the Xbox.

Interviewer: Um hmm Did any of the consoles or the games make you feel self-conscious? Or do you, were you aware that you were, you know, you were doing it you were playing the games in front of other people or any sort of feelings at all as such.

P1: You are more self-conscious of the Xbox because you you figure is on the screen initially, but then its just kind of that initial thing

Interviewer: Right

P1: on-screen

Interviewer: Yea

P1: but you get over that um so once people get used to that I think that won't be an issue.

Interviewer: Right

P2: With most people, the majority of people any way

P1: I agree with her you know

Interviewer: Yea

P2: because every if you have practiced for the Xbox you used to use this games so it would be no matter for that. But its its good experience to face yourself and you see how its going with the exercise you know. Its good. I found it like something its to be honest it is kind of fair you know so I am if I am gonna to do it or not if I am able to do it or not. That's it. because this is give you the ambitions if you err get more confident to go through the games you know.

Interviewer: uh uhu, right, so confidence in terms of uh how you perceived

P2: How you managed.

Interviewer: how you perceived yourself in the game and that game, obviously with the Nintendo it sets up a character for you but obviously with the Xbox it has a natural image

P1: Yes exactly

P2: Yes um hm.

Interviewer: a live image of yourself.

P2: What is usually different when you deal with people in front of you and you will see the natural movement from them you know doesn't seem like a game or any tv programme so its different you know.

P1: Someone who was really self-conscious might be put off by that.

Interviewer: Yea

P1: Like it might affect the way they play, they might not try very hard I guess erm, but I think most people would just get used it, overcome that and…

P2: You could see that. You could test people if they manage to do any movement before they are involved in the games and then you will transfer them to the games. Their ability, if they cannot perform the exercise before the games so they will not do any.

Interviewer: So you think it will be useful to kind of pick out the movements that are done in the games and get them get someone to try those movements first

P2: I think so yea

P1: um hm

Interviewer: Yea and then introduce them to the game to do those movements.

P2: Yep

P1:mm hmm

Interviewer: ok. That good.

P1: And also maybe get them familiarised with the fact that they are on the screen.

Interviewer: Yea like yea introduce them more to really what they are getting into

P1: Yea

Interviewer: Ok ye makes sense. Umm what would you change about them then. What would you change about the, lets start off with the Nintendo Wii. What would you change to make it to make it more engaging?

P1: (Breathes out) Well it doesn't pick up… you very well I don't think. There seems to be a delay.

Interviewer: Yea

P1: Um, that, you know, especially noticeable when you're kind of heading the ball I think

Interviewer: Yea, well I wonder because obviously we're meant to set up each participant with, it was a series of demographics if you like or characteristics that you can do but for the sake of the focus group we have actually erm we've just kind of, there are a set, there's a set like an average that its kind of used so

P1: Uh huh

Interviewer: It could be something like that, but I understand

P1: Yea if you put your height in or something like that then that might affect it. Um

Interviewer: so maybe just thought you weren't tall enough to head the balls

(General Laughter)

P1: Errm but my past experience with the wii, whenever you set a mii character up it didn't really, I don't think it affected it that much

Interviewer: Oh right ok, ok yea, fair one

P1: but I could be wrong, I could be wrong.

Interviewer: No no no

P1: I probably don't know enough about it.

P2: I mean um this kind of game is just depends about the person, for the people, whos how gonna to do it you know, if you're looking for if they can and how much they can performance you know, so, which is my opinion, I don't know if its agree with you or not but when you put people in these games, you know you will see how they can manage it. Is it zero percent? One, two, three? Or whatever they can, you know, so I think for my experience which is you could use it for first session to see how they are manage it.

Interviewer: um hmm

P2: If you gonna to put more erm … like intensities to use, some people cannot afforded that, you know, so, I, as I said its usually about the people.

Interviewer: um hmm

P2: We can say they can do that because put them in the first session as a trial and then you will see so put the percentage, this guy or this lady she can go through the whole exercises or she cant you know so this is about their ability.

P1: The thing is, you know as I was saying I do yoga and the balance that it was picking up on there from me was terrible.

Interviewer: Like not sensitive enough or? Too sensitive?

P1: Well it was really coming up as though it wasn't balanced at all.

Interviewer: Yea

P1: Umm

Interviewer: It didn't appear that way to be honest when I was observing. Is was saying 1 star as well

P1: Yea

Interviewer: and to be honest I thought you had done alright haha

P1: So did I haha.

(General Laughter)

P1: Do you know what I mean? So I just don't, I think the accuracy, I mean you're right I do think you can probably start people off on the Nintendo Wii erm to get an initial feel of what their capabilities are but its, to me it's not an accurate assessment of balance on there at all.

Interviewer: um hmm

P2: Think about something else that could be more you know, for the balancing.

P1: Yea is there nothing kind of slow and balanced on the Xbox?

Interviewer: On the Xbox yea, well I mean for the purpose of this study we had to use what was available

P1: um hmm

Interviewer: Um for future studies I would like to have something

P2: Ah you mean for the interventions available to the NHS so its different. If you were going to use it in the labs or you have to use this…but erm you could use erm the local something is like here to manage it. When you gonna start your erm data collection with peoples are you going to be with them here or in different places?

Interviewer: Oh err

P2: This is giving you the opportunity to what you going to use. So if you are here you could use anything. You could put your own imaginations. What tools are you wanting to use for this kind of conditions. So… I don't know whats the availability in the university or the others between physiotherapy and sport you could get more tools to use it and put them in the place you're going to use that's a lab you know so. Have you seen any err physio lab before to get engaged with the balance and exercise and stuff?

Interviewer: erm yes I have seen like a few a few online videos and stuff yes

P2: have to go direct to see err natural how they use it. If you could shadow them

Interviewer: Yea

P2: and ask them do they have any chance to see what's going on how they performing. It will give you more idea for this kind of people you are going to use interventions for instance for the parallel gait. You could have it here, why not? And people can perform their exercise through the Xbox with the parallel gait. So which is get the support for them for the first trial or sessions and then you remove the parallel gait. So people can manage to do it perfectly you know.

Interviewer: So who would you, if you had this at home, who would you most likely play with? and where abouts would you play? As in people.

P2: Xbox

Interviewer: You would play the Xbox

P1: Yea,

Interviewer: Preferably

P1: Yea

Interviewer: Yea ok

P1: I agree, erm, and what was the …?

Interviewer: So who would you find yourself playing with?

P1: (laughter) anyone who would?

Interviewer: Anyone who would?

P2: To be honest for me for me I haven't tried before but this is the first time. I would like to play with my kids, my daughters, so which is giving them erm more activities because they spending all the time at home so this is their new environment you know to do activities and exercise with some fun you know which is good.

P1: I'd probably do it on my own

(general laughter)

P1: My husband would probably just laugh at me

(general laughter)

P1: The dog would probably join in

(general laughter)

Interviewer: well it does pick up actually yea

P1: does it?

Interviewer: whenever something walks across so it might yea pick the dog up but I don't know if you will be able to keep him there for it.

P1: (Laughs) but yea I haven't got any children so I wouldn't I would have probably have to do it on my own

Interviewer: Yea…or friends

P1: or get my sister in or someone, yea friends or sister

Interviewer: and so would, do you think theres any safety concerns in terms of did you, your experience on either of the consoles, did you feel unsafe with any of them at all?

P1: Didn't feel unsafe but I think if you if especially the Xbox if you were using that at home you'd have to move you know kind of furniture that was in the way if you were doing it in your lounge or somewhere like that, you have to, you know, move the coffee table or the settee that bit further back to be able to you know to make sure that you could do it safely and not hurt yourself

Interviewer: Yea that makes sense. It takes up a bit more space than just the balance board

P1: Yes it does

P2: Um hmm because this is more and more intense yes um hmm

Interviewer: Umm ok, more in general as well, not, as opposed, not just the space but sort of safety with exergaming in general.

P2: Do you mean about the using exergaming

Interviewer: Yes, using it in general.

P2: The safety for that?

Interviewer: Yep

P2: I mean this is the, the games are not so connected or lying games so it is just system wise a machine you using the games. So I think there is no issue bout the safeties.

Interviewer: um hmm

P2: Is it? Do you mean for adults or anyone?

Interviewer: In in in in your views really

P1: Do you mean health wise or?

Interviewer: Yea health, Yea anything just yea

P1: I mean health wise, Nintendo Wii should be absolutely fine

Interviewer: Yea

P1: Xbox I think you can't just

Interviewer: Can't give it to anyone?

P1: No

Interviewer: No

P1: you know someone elderly or something like that or someone with some sort of issues with regards to I don't know, breathing problems or heart problems

Interviewer: So what issues do you think they might find, erm, unsafe if you like for the elderly in terms of for the Xbox? Any particular concerns that you would advise for that console?

P1: I mean, they'd have to be generally fit wouldn't they? They wouldnt have to heav any conditions like heart conditions or erm theres balances issues, I mean if someone had a walking stick or anything they couldn't they couldn't do that they couldn't play the Xbox,

Interviewer: Not that well

P2: It is difficult for people

P1: they could probably play the Nintendo Wii.

Interviewer: Yea more so the Nintendo yea

P1: hmm yea, so yea, have to be careful that way definitely

P2: Definitely yea because if you're going to pick the participant from community so you need to look the for the medical record for them you know to see what's going on if they have any other conditions so you may have to exclude more. So because this one I think is for the Xbox its more err accurate for healthy people to perform this kind of exercises you know so. But you could modified it because if there is a speed, if there is a speed and you could control the speed you could use it for the other people you know because they will follow the structures that you giving to them, you know, so which is err more effect for them but if you use it like this for the conditions that you going to follow. I think it's not

Interviewer: Yea I know I think it's a bit

P2: I disagree with that because I used to work with many people with various conditions so you cannot put them in this games you know so

Interviewer: Erm do you think any sort of visual erm, how can I say this? So in terms of instruction and scoring for the games. So just to compare the Xbox to the Nintendo Wii, would you say erm , could you tell me how you thought, was the screen too busy? Not busy enough? Was the instruction clear? Um how do you think they differed between the two different consoles?

P1: I think the instruction was clearer on the Nintendo Wii than it was, it was very busy

Interviewer: um hmm on the Xbox

P1: Maybe too many graphic and too many things going on with the Xbox than with the Nintendo.

Interviewer: Than with the Nintendo Wii

P2: The Xbox is something giving you more confusing so you have to focus about the movement that you are doing or what is going on the screens so because it is the screen is too busy so you cannot be giving more attention to the movement that you re gonna to make it you know so, but here it is more clear

Interviewer: um hmm

P2: I found this one it is the statistic, er statistic, statistic or static movement

Interviewer: Yea the static movement

P2: Static movement is more accurate so

Interviewer: Ok

P2: and much easier but this one if you are going to high, high level of performance you could use it

Interviewer: This one (Kinect)

P2: Yes

Interviewer: Ok, errm, so if you were to use any of them again and if you had to choose one, if you like, which one would you prefer to use or if you would prefer to use the Xbox for a particular reason and the Nintendo Wii for another type of reason. Erm just to have a think about.

P1: I think if I was wanting just a quick blast of aerobic exercise (laughs)

(general laughs)

P1: I would use the Xbox

Interviewer: Yea

P1: Erm, Nintendo Wii I think I'd probably use that for a bit of fun, rather than anything else, you know

Interviewer: So not like serious exercise

P1: No

Interviewer: or serious balance training or?

P1: No, no not at all

Interviewer: Ok

P1: Not at all. I didn't feel it was very physical

Interviewer: Right

P1: or demanding with regards to balance, even though my balance came out shocking.

(general laughs)

P2: Yea I agree yea yea the aerobic exercise giving you more opportunity to work with the balance and gaits you know so.

Interviewer: And is there anything else you'd like to say about exergaming in general and balance training. So using the console for balance training or erm things that you would improve, so, when I mentioned before about the score or anything at all?

P1: I think that theres definitely scope with regards to both consoles and games that are on the you know, that are within the packages that were, to help erm with health issues I think more than you know kind of erm maybe people with muscle issues or who've had injuries you know have balance issue from those injuries I think it might be beneficial erm but with regards to someone whos generally fit, I don't necessarily think they are going to be of any great benefit to them, erm I definitely think that if Xbox had you know kind of more slower game, slower, than what I experienced there, erm then that would be more beneficial as well.

Interviewer: Ok, do you think the same?

P2: Yea yea I think erm as I said about the speed from before because if you are gonna to use slow games you will get more beneficials about the games and exercise but also I will go back it depends about the people. The person who you work with for the scoring and erm I think if you gonna to start with a zero to five or five and ten or between zero and ten which is different from one to one so for the assessing it is important to start the scoring first and then you will see who will, this person in this game and the other person in that game so its variation between people you know but as err she said if its healthy so I think they use it just for fun you know, that's all, nothing more.

Interviewer: Ok, I think that's it thanks.

Focus Group 3

Interviewer (I) – Robin Tahmosybayat   Transcriber - Robin Tahmosybayat

Participants: (P1), (P2), (P3), (P4) and (P5)

I: Ok, so if you just like to start by telling me your name please? First name only.

P1: Kenneth

P2: Margaret

P3: Stephen

P4: Christine

P5: Keith

I: Thank you. Ok so um, first of all uh, what were your thoughts on exergaming before you came to this session? So exergaming is like exercise games. You are doing exercise through computer based methods, er, if one, when we do speak if you could possibly like have, try and do one at a time. I understand everyone, we are going to be having a conversation so... just do the best you can. Il be ok.

P5: To be honest I don't think I really thought about it.

I: Right. Um yea. So not thought about the concept before.

P5: no

I: Right ok, anyone else?

P1: I've seen the concept in the shops and that. You sometimes see demos and I though oh it's a good idea that but I never really knew how you get started with it so.

I: As in where you go to do it.

P1: Yea everybody seems an expert. You can either do it or you can't.

I: yea, so there's nothing kind of in between that mediates it.

P1: Yea

I: Right ok.

P2: I have had er, the odd try just with Gillian

I: Yea. Ofcourse

P2: My daughter. But apart from that I haven't done it myself.

I: No. Ok.

P3: Its pretty much just for kids.

I: Yea. So almost like commercial, like sort of the stuff you can get available in the shop. ok um... and which ok yea which did you like the most?

P2: I preferred uh

P4: the Wii

P3: the Wii

P2: this one

I: the Wii

P2: the wii

P3: the exergame

I: you liked the Xbox one, the kinect

P5: I think i preferred the kinect one as well

I: and you liked the kinect. ok.

P3: the wii

I: we got three wii's two kinects

P5: but is that just because the different type of, i mean could you get the games for there put onto the wii

I: Thats the things yea so, the games, they are not, they might be able to find some similar games but as far as I am aware, I mean you can get some yoga games for the kinect as well which is more like standing on the spot and doing certain poses but… um… yea so they are slightly different games, they ask different things from you but yes any particular game within the games. Lets start with the Wii, so did any one have like a particular game that they liked the most.

P2: I liked the football, the heading balls

I: The heading one yea

P1: I liked the ski jump.

(General Laughter)

I: The ski jump one yea.

P1: I could. One of these you can cotton onto quite quickly what you meant to be doing doing.

I: Yea. Yea Yea. yes its. It gets addictive I find. Because you always want to win. Um yep. any other games that you liked or

P4: I liked the ski slalom. I didn't like that one where you went in a bubble down the. Because as soon as you hit the side it stopped.

I: Ah the river bubble yea.

P4: It would have been better if it just kept going then told you how many times like the ski one.

I: Yea so almost like when you past a gate on the ski one its lets you carry on

P4: Yea lets you carry on

I: but the bubble one you kind of just sink.

P4: yea

P1: I think I found on that one the schematics weren't all that good but thats probably my eyesight or something like that

I: Right.

P1: That seemed a bit more simplistic to see like the heading the ball or the jumping

I: Yea

P1: Where as that seemed a lot of

P2: I found that easier to follow this one. Than that.

I: Um hm.

P2: I was a bit confused.

P1: That what seemed a lot of jazzy type stuff as if your in a disco mode sort of thing

I: Right yea. There is a lot going on screen with that one.

P5: Yea.

I: And the instruction's slightly different. Um. Any more thoughts like any other games? Like for example

P3: I liked the competition I like the competition that you could have on that. (XboxOne)

I: Yea, so yea the competitive side.

P3: Bring the competitive side out.

I: Yea

P4: Could you have that one (Wii) where you have two boards and have two play at the same time or not

I: You know thats a good question. As far as I'm aware you must be able to. I mean I havent tried it and I havent seen it but you must be able to because they are wireless.

P1: I think Ive seen it in the shop where you can play tennis on that one can't you.

I: Yea so this is the Wii fit programme

P1: Yea

I: and the Wii sports you can use to play tennis, boxing.

P1: Yea I think I have seen that in John Lewis playing tennis n that it looked quite interesting sort of thing, yea.

P2: I dont think it was on the board, it might of just been the hand things ive done when theres two of you and your competing.

I: And you both play next to each other yea.

P4: Well because I meant like there with two of you standing together doing the same thing.

I: Yea. Yea I know. The element of competition definitely has a part to play, yea.

P1: Can you not have the car racing games on them?

I: On these? um.

P1: Like to see in the Metrocentre when you both sit in a chair and your away racing in the moore or something like that.

I: Oh I love them.

(General Laughter)

P1: There there that sounds quite good. Yea I've seen them do it when they were kids

I: Yea.

P1: When they were kids, yea

I: Used to sit in like in one of the big formula one cars yea

P1: Yea yea that uh looked good sort of thing. You can knock each other off the track and stuff.

I: I'm not sure, I don't know actually. So thats sort of games, different types of interesting games as opposed to...

P1: Yea

I: What do you mean? You mean like to see different kinds of games on the balance board?

P1: Yea

I: Yea?

P1: Well I think it's games with an objective, as giving you something to do sort of thing, like thing Steve mentioned the competitive

I: Yea

P1: Sort of side of sort of ... side of got past the age of being physical with each other

(general laughter)

I: But still some competitiveness there. Um, did you find that the game trained balance at all? Uh, so any of them. So lets say which one do you think trained balance the most.? Like focus really zoned in on your balance.

P3: The Wii.

I: The Wii.

P3: The Wii

I: Definitely yea.

(General muttering of the Wii)

I: And um, how about the Kinect? Anything about the Kinect that you found to train balance at all?

P2: Made you sweat that one. (Laughter)

P1: Made you sweat. you got a good sweat. You got more of a sweat on with that one than you did with that one.

P2: Oh

I: Yea.

P1: Sort of thing

P2: I think you've conce.. you have to really concentrate on that.

P1: Yes. Yea

I: Yea I know I found that as well when I was playing it too.

P1: With that one you could get into the rhythm of what was going on like the board then on the ski jump

I: With the Wii?

P1: Yea, you can get into a bit of a rhythm with that one. Seems to be constantly changing.

P5: I think with the board one as well, you concentrate a bit more if you were doing it correctly whereas on that one, you basically just had to move out of the way of something.

I: Yea.

P2: Yea

P5: So whilst you're concentrating whether you are upright or down or anything or.

I: Yea

P5: When you went down, it wasn't checking your posture.

I: Right Yea.

P5: Or anything like that.

P1: Yea that one it had like a right answer to it didn't it.

P5: Aie

P1: You either headed the ball or you didn't and..

I: Um hm.

P1: and that was it so.

P3/5: and I didn't.

(general laughter)

P1: neither did I (laughs) well you jumped off the ski slope or you didn't sort of thing so

I: umm.

P1: Each point it was like an answer to what you have done and where as like Keith said with that one you weren't quite sure.

I: Sounds like you're saying that ones more structured,

P1: Yes.

I: to the gameplay has more structure on that one as opposed to this one (Wii vs Xbox one) and that screen seems quite busy.

P3: The Xbox what ever its called, that seemed to be more for general fitness and...

I: umm.

P3: and strength

I: Like aerobics

P3: The Wii seems to be more balance

I: umm. yea I know its true. So err I have had er... obviously with being limited to the platform you do kind of find, i mean, the nature of the game will almost be focused on just either swaying to the side, swaying to the left or something on the spot and this one I had seen we nearly had a fall.

(general laughter)

P4: Ai, ah ha (laughter)

I: Nearly, I think we had err... you managed to get your balance back in time, which is great! Yea so that was more stepping and stuff and jumping and definitely more competitive I found. Every time everyone was on there it was like right come on then lets go.

P4: Because you had two together

I: yeah yeah that one could be improved by having a dual...two balance boards together.

P1: That ones probably better one you can do on your own then.

I: umm

P1: Sort of thing

I: Yea because you might not be as motivated to do

P1: Yea on that you're like oh I've headed twenty balls, I'll see if I can get more.

I: Yea more physical

P3: Well thats a good point, with that one you may lose motivation if you are just doing it against yourself.

I: Yea

P3: You get to a point where I hit thirty thousand points thats

I: Right

P3: Im bored.

I: umm. That makes sense.

P1: That ones probably more relevant to sort of us type of people like we play football or ski stuff like that so its a bit more like real life, personally, I'm not a dance person or anything so.

(General laughter)

P3: Depends what you want, I mean if its general fitness i guess its that one (Xbox One)

I: Umm.

P3: If its balance and posture its the...the Wii.

I: Yea.

P1: You probably need a mix of both

I: Yea so there are elements. I was just about to say.

P1: You warm up on that one (Wii) then you go play your game on there (Xbox One)

I: So there are elements of the Wii, which is its mainly static balance. So but the Kinect is training balance while you are moving so its a bit more dynamic in that sense.

P1: Presuming the Wii one you could have like exercise games in there.

I: Yea

P1: I'll want a warm up exercise sort of thing and then I'll go play a game on sort of thing.

I: Yea... Yea no I I think i think there are. So obviously the Wii sports will be more sort of fitness and I think there is some fitness programmes you can get on there as well so... so that is good. Any thoughts on this game (MIRA)?

P5: I thought the er demonstration at the front was quite good but um obviously well there was some teething problems with people weren't doing it right.

I: Umm.

P1: The controls weren't very good on it were they.

P4: Um hmm. The graphics and that weren't as good. You can tell thats just new.

I: You can tell yea between these

P4: Like they haven't tweaked it yet.

I: Umm. Well I guess thats it, obviously with it, with that being a games company, that being a massive games company, you are going to get better graphics than this. But any sort of um... the types of movements it was making you do in comparison to these (Wii & Xbox One) two.

P3: Similar to the Wii

I: Yea more so.

P4: It was specialising in one area wasn't it

I: Umm.

P4: If you, you need to exercise your hip you could find an exercise on there

I: Which is just for your hip, yea.

P4: Just at the hip

P2: Like that neck one

P4: You were saying that neck one

P2: Laughter

P4: Where you had to keep the rest straight didn't you

I: Yea

P4: And just move your neck

I: And obviously we've just had a few days to have a play with it so we are not sure if its teething problems with the actual game or if it's actually saying no you are doing that movement wrong as if you have got a physio there going no you have to, no you need to.

P4: So if that was right with the neck one it was very accurate because it wouldn't register unless you were just moving

P2: No. No just. just my neck so if you move the rest of your body, obviously it can sense it.

P4: It didn't work.

P3: It does. It gives you feedback at the end so you know where you're at.

I: Right

P3: So you know your baseline on day one is ... what ever it is...then you can see

I: yea

P3: if you're progressing, if your getting any better or its not working for you.

I: and you can do that one with the Wii as well, um but obviously that ones more, you set yourself up there first and then it kind of does, it tells you at the end of the session and there is some data you can see as well, which I don't know if we are going to have time to have a look today but I'm getting vibes that you are tailored more towards this (Wii) than this (MIRA) at the minute, which is um, I think the game play's quite similar between these two compared with that one (Xbox One) i'd say. But i'd just, maybe, how do you think others might feel about it? So er you have got family, you've got friends, maybe you have got a friend who is injured or children, grandchildren?

P5: Children would be that one

I: Yea

P5: Anybody who was injured would probably veer toward that one to give you, to specify what your injury is I suppose.

P1: And it's giving you information or like you say (P5) if its recording you can come on the next day and you can play

I: Yea

P1: you can see if you are getting somewhere. So its actually like going to physiotherapist almost

I: Almost, yes thats the idea.

P3: Some of these things you think they should put in the care homes.

P1: Thats what I was saying yea.

I: Yea thats what I am going to hopefully be doing

P3: You know instead of them sitting about static all day while they could do some of them in chairs.

P1: Well I have. All my parents are now in a care home and they are either sitting watching tele or someone used to come along and do a bit of exercise with them but its all just like this (?) whereas that theres a bit of competitive. I think people are still competitive doesn't matter how old they get.

P5: Yes precisely

P1: You see them playing cards and dominoes and stuff like that. and you can do stuff like that without thinking. Myself and Margaret were just getting a sweat on here without trying, whereas if you just sitting doing this, you can see they fall asleep whereas that it makes you concentrate, so keep on doing it sort of thing. Its like ohh I had better not stop it will get us sort of thing.

P3: They could tailor it, sort of slow the speeds down.

I: As in yep, yep this one?

P3: That's a bit rapid

P1: Yea

P3: You know if you're ninety year old that'll be a bit rapid for you.

P5: (Laughs)

I: Oh yea. Absolutely.

P1: Or anything like that where it makes it... I can imagine two or three old blokes heading the ball and stuff like that but was slowed down and that.

P2: Oh yea

I: and so out of the three, which one do you think you would most likely play if it was you on your own or in your pair or with friends.

P2: I think I would play the Wii

I: The Wii as well.

P3: I think I'd use the Wii more

I: Yea. Umm.

P3: Even though I preferred that game for the competitive side.

I: Yea

P3: If I was on my own...that... because its all about balance and you can see improvement.

I: and maybe if there was a game more tailored, similar to that sort of balance where you are standing and you are focussing whilst trying to maintain your balance or stability yea. Ok... so what changes would you make to any of them. Any of the consoles er maybe just to improve them then, to... or ... between these. We will do the Wii vs the Kinect first, so which one would you?... What would you change about the Wii in terms of the set up or the controller or the balance board or...?

P3: Different levels so if you had basic, intermediate, expert.

I: Right ok. For... yea for the gameplay.

P1: For the game.

P3: Like heading of the footballs in, you are going in and you don't know if thats like an expert level or where you're at...

I: Right

P3: Whereas you start at the very low level...

I: Then sort of build your way up

P3: ...get the hang of it and build and build up.

I: Um. Yea that makes sense yea. And the Kinect (Xbox One)? This one.

P3: Pretty much the same with that. If you could start at a slower speed.

P1: I found the screen too busy on that one

I: Right, yea.

P1: Sort of thing that couldn't gage into my vision.

P2: It seemed to have a lot going on

P1: Yea thats it you see. Lots of garish flashing lights involved among it I found it a bit distracting sort of thing

P3: Christine and I spotted on that one where you were picking the melons

I: Yep

P3: There was actually a bar at the side telling you which melon to go for.

P4: but We didn't know that until the end

P3: We didn't know that until the end

I: Yes didn't I tell you that

P4: It wasn't explained to you

I: Right ok.

P2: Thats quick isn't it.

I: Yea that makes sense

P2: I don't think you notice how tiny it is.

I: You know I have done this three times now and its the first time I have noticed it too.

(general laughter)

I: So... its not explained in the tutorial though.

P4: Ai yea.

P3: No its not no.

I: So that is something they need to pick up on

P2: I think thats a lot quicker as well and you are trying to concentrate that much and I think you can miss things like those melons I was just...

P1: Yea sometimes you are just scoring points and you didn't really know why you were scoring points (laughing)

P2: I just tried to bite

I: That one you did? (Wii)

P1: Yes that was very definite on what you did.

P3: The Wii's a lot clearer.

P1: Yes

P2: Out of the two I think

P1: Could be like Steve said, that could be at a professional level or something daft like that

P2: Coz even the scores and that I didn't really understand the ... you know... at the end.

I: How... how it works.

P4: It was in the thousands wasn't it. Some of them...

P5: I didn't know how

I: Yea

P1: So if you'd ...if you'd played the game again it give you a different score.

I: Yea

P1: You none the wiser how you got there

I: Have I improved. Obviously I have improved but I'm not quite sure how I did.

P1: Yea I don't know how I did. With the Wii it was quite simplistic, you either head the ball or you don't sort of thing.

P2: Mm hm (agrees)

P2: Or you miss the ski slope

(General Laughter)

P2: Yea thats right, you got the nack of it. It was quicker to get the nack on that one I think.

I: Hm

P3: One of the games with the squats?

I: Yea

P3: I mean I was way ahead of Keith on the squats, but no we had the same squats but Keith was miles ahead on the final score but

I: So you had the same amount of squats

P2: Yea

P3: You couldn't work out...

I: Yea

P3: how's he... how's he so far ahead?

I: Far away yea

P1: You couldn't figure out what to do to improve yourself on it.

I: In terms of safety of using the console, uhh just yea any sort of anything pop up in your mind whilst you were playing or whilst you were watching someone else?

P4: I just think with the Wii if thats old people standing on that thing...

I: Yea, on the balance board

P4: They might fall off

I: Mm

P4: Its not that big

I: So maybe's if their was like a support nearby just incase for balance if they felt they were going to go

P2: Yea

P3: Maybe's even if it was recessed into the floor

I: Into the floor

P3: There would be no tripping area for them.

I: I have heard of a study where they have done something like that before

P3: Yea as Christine says if they wouldn't fall over

P2: Yea these older people they need like on the running machines. You nee a couple of bars you could grab hold of.

I: and how do you think that would, if you knew you had that there...would you feel more confident playing say that or even the Xbox if you had a support in front of you like a bar running parallel to the movement so if you are going side to side you can always grab the bar if you.. if you have a movement going (points to the side)

P4: I mean it'd be better if they just had like a mat.

I: A mat yea. Yea so you knew that there was yea

P4: Just a flat mat, yea

P3: The Xbox I don't think would be appropriate in like a care home because its too fast.

I: Yea

P5: I don't think they will either

P3: They are jumping all up and down and squatting

P4: They maybe like bump into each other

I: Yea its not targeted to that audience is it.

P3: Well that one you can see the advantages of that one (Wii) because you can go as fast or as slow as you want.

I: Yea, that makes sense

P1: And this is the type of thing you can just come along and play on, you know, and on the way by oh I'll have a go at this, whilst nobody's looking sort of thing.

I: Especially I think when you do set up the Mii character, is what they are called, it's a lot more personalised for yourself but for the sake of today we only had a few hours so I just didn't want do it because it would take forever in a day but I think that improves the accuracy of it and so maybe that could change the perception of how you play on and when you play on a game. But one thing I want to pick up on quickly is what you said whilst you were playing on the Kinect. You mentioned that it was quite difficult but once you had a few goes at it you soon found yourself in rhythms which is what I was kind of... it was an interesting point to pick up on because that is more rhythmic I think in terms of timing, like you were saying its more aerobic, its more rhythmic and this one was more just focus and concentrate so more balance and this one more like... rhythm. Did you feel any anxious whilst you were playing any of the consoles?

(General murmuring of "no")

I: No? ok.

P1: It helps that you are know people

I: Yea so maybe's if you were in a group with, if I had just recruited random and one of you had only come and you were with other people would you feel self-conscious in front of them playing the games? Or self.. or looking on-screen, seeing yourself on screen, or any sort of feelings towards it?

P2: I think at our age you're not really bothered anymore, you don't care. You're not bothered about making a fool of yourself, you doing it all your life to some extent haven't you.

I: Yea

P1: Laughs

I: Yea

P2: Probably for younger people it's a bit more difficult

I: Well I have had some people say it yea so. Ok so it might seem like a silly question but which would you take home and use like tomorrow?

P2: I'd take that one (Wii)

(General consensus on: The Wii)

I: I think we all agree on the Wii haven't we.

P5: Well it depends if you were doing, if you'd been told you had to do some rehabilitation then maybes that one over there

P1: Rehabilitation yea

I: Yep

P5: Uh and then presumably you'd be given certain exercises on the left hand side (left hand window in MIRA web based platform)

I: Yea

P5: and the games you work your way through

I: Yea you can actually, you can play the same game with several different exercises so if you liked a particular game, you'd probably be able to do it with say you had shoulder problems and hip you could probably do it with both if you liked that game and you can schedule... one thing I noticed is that you can schedule sessions so all the games in a session you just select them all or the physio can do it for you and then you'll just basically... they will send it online if you have one set up at home and then they just, you click and they bring it all up for you.

P5: Oh right

I: So hopefully thats the direction we will try to go in.

P1: The good thing that Keith mentioned about that is that it makes you do it properly because we have all had physio and I did my achilles and you go somewhere and they tell you to bend like that then they walk away and leave you and just like do ten of them and you don't know if you have done them right.

I: Do they actually walk away? Do they not watch?

P1: Not when I did mine.

P3: Show you once, give you a sheet then send you home

P1: Yea

I: Right ok

P1: Yea you do stuff at home and you don't actually know if you are doing it right

I: Mm

P1: whereas that is watching you all the time

I: Feedback, Feedback

P1: Going wrong wrong, yea yea so its quite good

P1: It did you with your neck didn't it

P2: Yea (Laughs)

I: I think yea because it's the type of camera it is as it puts little dots all over you so it'll know if your shoulder is moving more so than the Wii might know for example because its just about the pressure you're putting on the board. But ok so. Anything else that you want to add about exergaming or balance training um

P3: Well if its aimed at physiotherapy it drive the right behaviours because you've... you're getting your're instant feedback and you're also getting presumably feedback from the physio because they'll be getting

I: The sheets of information

P3: you to do it more often less often or stretch more. As things go on you can tailor it so what ever you are flexing you can flex more.

I: And yea it kind of tracks you like that.

P1: You can actually record the people that had done it as well because I remember when I was doing mine, you're going back thirty years ago, they'd show you the exercises to do and they'd wander off and they say now they not looking. How does that prove (laughs) that they ...

I: Yea. yea you can't get away with it on that one

P1: If its told you to do 20 knee bends

I: Yea

P1: Then it will record it and therefore you're not fooling anybody, you can't sort of see the physio and say I've done all the knee bends, I'm no better. He'll say sorry you've only done 10 son.

I: Yea

P1: Its your own personal physio

I: Well yea I think that's essent... I think that's what they are trying to move towards so... that kind of started it all off really with the Nintendo in 2008 and so I think. I think they might have used that platform more so than that one to kind of develop this sort of game really.

P3: Well the quicker that comes out the better because if you ever want to make a physio appointment

I: Yea

P3: Make it before you break something

I: Whats the waiting time?

P2: Its quite a while

P3: Its about 9 weeks

I: Right ok. Wow.

P5: Is that NHS though?

P3: Aie, well I'm not going to pay for it.

P4: (Laughs)

I: Yea

P1: I think it would be a very good personal physio machine that

I: Yea, I know I think that's what the idea is

P2: Because it tells you if you are doing it wrong or

P1: Its exactly what you want

I: The aim of what I'm going to do after this study is take it into a sheltered accommodation and residential accommodation, not nursing care yet, but so we just going to, we are trying to see if we can just set up in the communal room and then say right I'd like you to come at these times and these times and obviously I'll be there and I'd like you to come and have a game and just kind of... just... I guess everyone can kind of come at their own time and have a go and so we want to see if it works like that first before really putting into peoples rooms on their own because really thats good but its the social influence that really will keep yea.. keep you training.

P1: I think that ones more for mentoring you can see for what I can see (MIRA)

I: Right

P1: Yea quite good if you've hurt your leg or if you

I: That more once you've broken something

P1: Yea once you... yea. Whereas that, the Wii it becomes a bit of a social thing, doesn't it. Its a way of getting people to interact a bit sort of thing and have a laugh.

P3: And improve their balance

P1: And improve yea on the way by yep.

I: Definitely, what about competitiveness with that one? It's not really...

P4: No

P3: No

I: Because it's designed to

P4: That's what I'm saying it's just a bit flat at the minute but then if it gets improved

I: Yep well I can imagine obviously if you are starting a programme, over the weeks you will get used to the games a bit more and you'll get used to the movements so that sort of thing with any of them would help you improve. Do you think the graphics, you said were quite

P5: Take a while back

I: Old school like yea not

P4: The team

P3: Nineteen seventies

(general laughter)

P4: Aie you can tell its

I: Like Pacman or?

P4: It needs upping a bit

I: Yea and what about the instructions did you think it was clear? Or...

P4: Well you got mixed up didn't you

P3: I got mixed up

I: Yea. See thats it. I don't know if its the demo so I'd like to investigate that a little bit further. What about the other two for instruction?

P2: That one felt easier (Wii)

P4:Well that one no because we didn't know if they were boxes or if they were melons

(laughter)

I: So the Xbox is not very good

P2: With that one I was a bit confused

P3: That was too intuitive (Xbox)

I: Because I have had a look at both and there is the same information on both screens er, it's just some of the text on that screen's tiny.

P1: Yea

(General agreement)

I: I found. That one you press A and then it flies off doesn't it

P2: Yea

P5: That one waits until your ready to go (MIRA) whereas that one

I: Mm yea, it's like 3,2,1.

P2: You don't really have time for that it just starts doesn't it.

P4: Just starts

I: Definitely more sweaty on this one

P1: I think that ones a bit more logical to people like us. Its... in a way as he said thats more intuitive (Xbox)

I: Well you know the tightrope game

P1: Yea

P2: Yea

I: Where you had to step and you had to lean, well we've only had one person, so I have done three focus groups, one youngens and then middle aged and I done its like... older and the only person who has done it is a girl from the 18-29 years olds and she literally just managed it so I think it is quite challenging that one.

P2: Oh it is

P3: Thing is, once you go you go

(General Laughter)

I: Just check what time it is.

P1: It's uh...five to 1.

I: Ok thanks. So I know we are tight for schedule like but have you got anything else that you want to say at all? Have you enjoyed it?

P3: Oh yea its interesting, its good.

P2: Oh yea

I: Hopefully

P1: I think you said as well it's not just physical exercise, its mentally as well. Its making you concentrate which you're not used to because we don't work for a living anymore sort of thing (laughs)

P2: (Laughs)

I: So hand eye coordination was training a bit as well

P1: Yea... Yea but it's actually making your brain work

I: Mm

P4: That butterfly one (MIRA) was like that

I: Yea.

P4: You know you...

I: I wish we had a bit more time because some games on that one where the they dual task you so they say right I want you to do these movements but I want you to think backwards in two's or something like that or memory games and stuff like that.

P3: Well thats like going up the general hospital to do them ones

I: Yea?

(General Laughing)

P2: Oh I don't like them ones

I: Like Sudoku or something like that yea

P1: Yes but you need to stimulate your brain as you are getting older sort of thing otherwise you become lazy.

I: Well thank you very much for coming down guys you have been very helpful.

P3: You’re welcome.

9.9 Appendix I

TIDieR
Template for Intervention Description and Replication

The TIDieR (Template for Intervention Description and Replication) Checklist*:

Information to include when describing an intervention and the location of the information

Item number	Item	Where located ** Primary paper (page or appendix number)	Other † (details)
	BRIEF NAME		
1.	Provide the name or a phrase that describes the intervention. – *Exergaming to improve postural control in community dwelling older adults (Mira Exergaming (MirEX Trial))*	Page 139	______________
	WHY		
2.	Describe any rationale, theory, or goal of the elements essential to the intervention.	Pages 139-141	______________
	WHAT		
3.	Materials: Describe any physical or informational materials used in the intervention, including those provided to participants or used in intervention delivery or in training of intervention providers. Provide information on where the materials can be accessed (e.g. online appendix, URL).	Pages 145-148	______________
4.	Procedures: Describe each of the procedures, activities, and/or processes used in the intervention, including any enabling or support activities.	Pages 145-148	______________
	WHO PROVIDED		
5.	For each category of intervention provider (e.g. psychologist, nursing assistant), describe their expertise, background and any specific training given.	Pages 143-144	______________

	HOW		
6.	Describe the modes of delivery (e.g. face-to-face or by some other mechanism, such as internet or telephone) of the intervention and whether it was provided individually or in a group.	Pages 145-148	______________
	WHERE		
7.	Describe the type(s) of location(s) where the intervention occurred, including any necessary infrastructure or relevant features.	Pages 143-144	______________
	WHEN and HOW MUCH		
8.	Describe the number of times the intervention was delivered and over what period of time including the number of sessions, their schedule, and their duration, intensity or dose.	Pages 145,147	______________
	TAILORING		
9.	If the intervention was planned to be personalised, titrated or adapted, then describe what, why, when, and how.	Page 145-148	______________
	MODIFICATIONS		
10.[ǂ]	If the intervention was modified during the course of the study, describe the changes (what, why, when, and how).	____N/A______	______________
	HOW WELL		
11.	Planned: If intervention adherence or fidelity was assessed, describe how and by whom, and if any strategies were used to maintain or improve fidelity, describe them.	Page 156	______________
12.[ǂ]	Actual: If intervention adherence or fidelity was assessed, describe the extent to which the intervention was delivered as planned.	Pages 161-162	______________

** **Authors -** use N/A if an item is not applicable for the intervention being described. **Reviewers** – use '?' if information about the element is not reported/not sufficiently reported.

† If the information is not provided in the primary paper, give details of where this information is available. This may include locations such as a published protocol or other published papers (provide citation details) or a website (provide the URL).
ǂ If completing the TIDieR checklist for a protocol, these items are not relevant to the protocol and cannot be described until the study is complete.

* We strongly recommend using this checklist in conjunction with the TIDieR guide (see *BMJ* 2014;348:g1687) which contains an explanation and elaboration for each item.

* The focus of TIDieR is on reporting details of the intervention elements (and where relevant, comparison elements) of a study. Other elements and methodological features of studies are covered by other reporting statements and checklists and have not been duplicated as part of the TIDieR checklist. When a **randomised trial** is being reported, the TIDieR checklist should be used in conjunction with the CONSORT statement (see www.consort-statement.org) as an extension of **Item 5 of the CONSORT 2010 Statement.** When a **clinical trial protocol** is being reported, the TIDieR checklist should be used in conjunction with the SPIRIT statement as an extension of **Item 11 of the SPIRIT 2013 Statement** (see www.spirit-statement.org). For alternate study designs, TIDieR can be used in conjunction with the appropriate checklist for that study design (see www.equator-network.org).

9.10 Appendix J

CONSORT 2010 checklist of information to include when reporting a pilot or feasibility trial*

Section/Topic	Item No	Checklist item	Reported on page of Chapter
Title and abstract			
	1a	Identification as a pilot or feasibility randomised trial in the title	Page 139
	1b	Structured summary of pilot trial design, methods, results, and conclusions (for specific guidance see CONSORT abstract extension for pilot trials)	N/A
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale for future definitive trial, and reasons for randomised pilot trial	Pages 139-141
	2b	Specific objectives or research questions for pilot trial	Page 141
Methods			
Trial design	3a	Description of pilot trial design (such as parallel, factorial) including allocation ratio	Page 142
	3b	Important changes to methods after pilot trial commencement (such as eligibility criteria), with reasons	Page 142
Participants	4a	Eligibility criteria for participants	Page 143-144
	4b	Settings and locations where the data were collected	Page 155
	4c	**How participants were identified and consented**	Pages 143-144
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	Pages 145-148
Outcomes	6a	**Completely defined prespecified assessments or measurements to address each pilot trial objective specified in 2b**, including how and when they were assessed	Pages 148-156
	6b	Any changes to pilot trial assessments or measurements after the pilot trial commenced, with reasons	Page 142
	6c	**If applicable, prespecified criteria used to judge whether, or how, to proceed with future definitive trial**	

Sample size	7a	**Rationale for numbers in the pilot trial**	Page 156
	7b	When applicable, explanation of any interim analyses and stopping guidelines	N/A
Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	Page N/A
	8b	Type of randomisation(s); details of any restriction (such as blocking and block size)	N/A
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	N/A
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	N/A
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how	Page 156-157
	11b	If relevant, description of the similarity of interventions	Page 146-148
Statistical methods	12	**Methods used to address each pilot trial objective whether qualitative or quantitative**	Page 157-158
Results			
Participant flow (a diagram is strongly recommended)	13a	**For each group, the numbers of participants who were approached and/or assessed for eligibility, randomly assigned, received intended treatment, and were assessed for each objective**	Page 158-159
	13b	For each group, losses and exclusions after randomisation, together with reasons	Page 158-159
Recruitment	14a	Dates defining the periods of recruitment and follow-up	Page 158
	14b	Why the pilot trial ended or was stopped	Page 158
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	Pages 160-161
Numbers analysed	16	For each **objective**, number of participants (denominator) included in each analysis. If relevant, these numbers should be by randomised group	Page 159
Outcomes and estimation	17	For each objective, results including expressions of uncertainty (such as 95% confidence interval) for any estimates. If relevant, these results should be by randomised group	Page 164-193
Ancillary analyses	18	Results of any other analyses performed **that could be used to inform the future definitive trial**	N/A
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	Page 193
	19a	If relevant, other important unintended consequences	N/A

Discussion			
Limitations	20	Pilot trial limitations, addressing sources of potential bias and remaining uncertainty about feasibility	Page 194-195
Generalisability	21	Generalisability (applicability) of **pilot trial methods and findings to future definitive trial and other studies**	Page 195
Interpretation	22	Interpretation consistent with **pilot trial objectives** and findings, balancing **potential** benefits and harms, and considering other relevant evidence	Page 195
	22a	**Implications for progression from pilot to future definitive trial, including any proposed amendments**	Page 194-198
Other information			
Registration	23	Registration number for pilot trial and name of trial registry	N/A
Protocol	24	Where the pilot trial protocol can be accessed, if available	N/A
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	N/A
	26	Ethical approval or approval by research review committee, confirmed with reference number	Page 142

Citation: Eldridge SM, Chan CL, Campbell MJ, Bond CM, Hopewell S, Thabane L, et al. CONSORT 2010 statement: extension to randomised pilot and feasibility trials. BMJ. 2016;355.

*We strongly recommend reading this statement in conjunction with the CONSORT 2010, extension to randomised pilot and feasibility trials, Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up to date references relevant to this checklist, see www.consort-statement.org.

9.11 Appendix K

Ethics approval email.

Submission Ref: 706

Following independent peer review of the above proposal, I am pleased to inform you that **APPROVAL** has been granted on the basis of this proposal and subject to continued compliance with the University policies on ethics, informed consent, and any other policies applicable to your individual research. You should also have current Disclosure & Barring Service (DBS) clearance if your research involves working with children and/or vulnerable adults.

The University's Policies and Procedures are here

All researchers must also notify this office of the following:

- Any significant changes to the study design, by submitting an 'Ethics Amendment Form'
- Any incidents which have an adverse effect on participants, researchers or study outcomes, by submitting an 'Ethical incident Form'
- Any suspension or abandonment of the study.

Please check your approved proposal for any Approval Conditions upon whichapproval has been made.

Use this link to view the submission: View Submission

Research Ethics Home: Research Ethics Home

Please do not reply to this email. This is an unmonitored mailbox. Queries should be forwarded to ethicssupport@northumbria.ac.uk

9.12 Appendix L

INFORMED CONSENT FORM

Project Title: An investigation into the feasibility of exergaming as a means to improve postural control in people aged 60 years and older, living in the community.

Principal Investigator: Robin Tahmosybayat

I hereby confirm that I give consent for the following recordings to be made:

Recording	Purpose	Consent
Voice recording	To record thoughts and opinions of individuals within a group discussion based on different Exergaming modules for training balance.	

Clause A: I understand that no one else will hear the recording(s). The recordings will not be conveyed to me. My name or other personal information will never be associated with the recording(s).

Tick or initial the box to indicate your consent to Clause A ☐

Clause B: I understand that the transcript(s) may also be used for teaching/research purposes and may be presented to students/researchers in an educational/research context. My name or other personal information will never be associated with the recording(s).

Tick or initial the box to indicate your consent to Clause B ☐

Clause C: I understand that the full transcript and recording will be a confidential document. However, quotes from the transcript may be published in an appropriate journal/textbook or on an appropriate Northumbria University webpage. My name or other personal information will never be associated with the transcript(s). I understand that I have the right to withdraw consent at any time prior to publication, but that once the recording(s) are in the public domain there may be no opportunity for the effective withdrawal of consent.

Tick or initial the box to indicate your consent to Clause C ☐

please tick or initial where applicable

I have carefully read and understood the Participant Information Sheet.	☐

I have had an opportunity to ask questions and discuss this study and I have received satisfactory answers.	☐
I understand I am free to withdraw from the study at any time, without having to give a reason for withdrawing, and without prejudice.	☐
I agree to take part in this study.	☐

Signature of participant.. Date.....………………..

(NAME IN BLOCK LETTERS)...……………………….

Signature of researcher.. Date.....………………..

(NAME IN BLOCK LETTERS)...……………………….

9.13 Appendix M

Overview of exergame training during the MirEX trial on a week by week basis

Intervention length = twice weekly for 6 weeks

Individual session breakdown = 45 minute session. 30-minute schedule. 20-24 games depending on participants capabilities.

Individuals that struggled with certain movements were encouraged to attempt with support. If this was also deemed too difficult, then the movement was changed for that participant for the same duration of time. The movements were kept the same each week and in the same order, however, certain movements were replaced upon reflection and discussion with the participant in some cases. Some games were changed which altered the intensity at which repetitions were conducted. Games were structured for the participant and the difficulty level increased week by week depending on the capabilities of the participant. All participants were capable of ambulation without an aid but had fallen twice in the last 12 months. Participants came to Northumbria University for the exergaming visits.

Week 1 Schedule:

Participants will undergo this schedule whereby the settings will begin on “easy” and the movements chosen were those most closely related to training balance. Some exercises may be changed in the second week of training or immediately depending on the participant.

Table 1: Mira week 1 schedule displaying characteristics of exergames and movements of SFPC trained

Movement	Game	Duration (s)	Difficulty	Support provided (Y/N)	Component of the SFPC trained (1-9)
Spine frontal flexion	Atlantis	60	E	N	1,3,4,9
Spine lateral flexion	Animals	60	E	N	1,3,4,9
Spine general	Airplane	60	E	N	1,3,4,9
Lateral weight shifting	Colour clouds	120	E	N	1,3,4,9
Full body turn	Follow	60	E	N	3,4,6,7,9
Side steps	Catch	120	E	N	1,3,4,6,7,9
Walking (on the spot)	Izzy the bee	120	E	N	3,4,6,7,9
Functional Reach R	Grab	120	E	N	1,2,3,4,6,7,9
Functional Reach L	Grab	120	E	N	1,2,3,4,6,7,9
General full body	Basket ball	60	E	N	1,2,3,4,6,9
Knee flexion R	Fishing	60	E	Y (single chair)	1,2,3,4,6,9
Knee flexion L	Fishing	60	E	Y (single chair	1,2,3,4,6,9
Lunges	Task Swap	60	E	Y (dual chair)	1,2,3,4,6,7,9
Side taps	Forest leaves	120	E	N	1,2,3,4,6,7,9
Sit to stand	Power house Bid	120	E	N	2,3,4,6,7,9
Hip general R	Juggar	120	E	Y (single chair)	1,2,3,4,6,9
Hip general L	Juggar	120	E	Y (single chair)	1,2,3,4,6,9
Hip abduction R	Piano	60	E	Y (single chair)	1,2,3,4,6,9
Hip abduction L	Piano	60	E	Y (single chair)	1,2,3,4,6,9
Proprioception L	Butterfly	60	E	N	1,2,3,4,9
Proprioception R	Butterfly	60	E	N	1,2,3,4,9

15 seconds rest between each game. All participants began on the lowest difficulty level.

Week 2 Schedule:

Red text refers to exclusion and green text refers to inclusion. For P07EX knee flexion right and left (60s) was swapped out for walking (120s) and the lunging exercise was swapped for weight-shifting (60s) as there were safety issues with the movement for this participant (85 years) regarding arthritic knee pain.

Table 2: Mira week 2 schedule displaying characteristics of exergames and movements of SFPC trained

Movement	Game	Duration (s)	Difficulty (E, M, H)	Support provided (Y/N)	Component of the SFPC trained (1-9)
Spine frontal flexion	Atlantis	60	M	N	1,3,4,9
Spine lateral flexion	Animals	60	M	N	1,3,4,9
Spine general	Airplane	60	M	N	1,3,4,9
Lateral weight shifting	Colour clouds	120	M	N	1,3,4,9
Full body turn	Follow	60	M	N	3,4,6,7,9
Side steps	Catch	120	M	N	1,3,4,6,7,9
Walking (on the spot)	Izzy the bee	120	M	N	3,4,6,7,9
Hip abduction R	Piano	60	E	Y (single chair)	1,2,3,4,6,9
Hip abduction L	Piano	60	E	Y (single chair)	1,2,3,4,6,9
Functional Reach R	Grab	120	M	N	1,2,3,4,6,7,9
Functional Reach L	Grab	120	M	N	1,2,3,4,6,7,9
General full body	Basket ball	60	M	N	1,2,3,4,6,9
Knee flexion R	Fishing	60	M	Y (single chair)	1,2,3,4,6,9
Knee flexion L	Fishing	60	M	Y (single chair	1,2,3,4,6,9
Lunges	Task Swap	60	E	Y (dual chair)	1,2,3,4,6,7,9
Side taps	Forest leaves	120	M	N	1,2,3,4,6,7,9
Sit to stand	Power house bid	120	E	N	2,3,4,6,7,9
Hip general R	Juggar	120	M	Y (single chair)	1,2,3,4,6,9
Hip general L	Juggar	120	M	Y (single chair)	1,2,3,4,6,9
Hip frontal flexion R	Izzy the bee	60	E	Y (single chair)	1,2,3,4,6,9
Hip frontal flexion L	Izzy the bee	60	E	Y (single chair)	1,2,3,4,6,9
Proprioception L	Butterfly	60	M	N	1,2,3,4,9
Proprioception R	Butterfly	60	M	N	1,2,3,4,9
Lateral weight shift	Colour blocks	120	E	N	1,3,4,9
Side steps	Colour blocks	60	E	N	1,3,4,6,7,9
Side steps	Fire fly	120	E	N	1,3,4,6,7,9

15 seconds rest between each game. All participants began on the lowest difficulty level.

Week 3 Schedule:

Movements remain the same and in the same order but have changed the games around and added a few new games. This altered movement intensity but maintained movement familiarity and volume. By changing the game element we were able to introduce a new cognitive challenge (shaking things up).

Table 3: Mira week 3 schedule displaying characteristics of exergames and movements of SFPC trained

Movement	Game	Duration (s)	Difficulty (E, M, H)	Support provided (Y/N)	Component of the SFPC trained (1-9)
Spine frontal flexion	Fishing	60	M	N	1,3,4,9
Spine lateral flexion	Memory scape	60	M	N	1,3,4,9
Spine general	Seasons	120	M	N	1,3,4,9
Lateral weight shifting	Move	120	M	N	1,3,4,9
Full body turn	Flight control	60	M	N	3,4,6,7,9
Side steps	Nback	120	M	N	1,3,4,6,7,9
Hip abduction R	Animals	60	M	Y (single chair)	3,4,6,7,9
Hip abduction L	Animals	60	M	Y (single chair)	1,2,3,4,6,9
Functional Reach R	Grab	120	M	N	1,2,3,4,6,9
Functional Reach L	Grab	120	M	N	1,2,3,4,6,7,9
Knee flexion R	Task swap	60	M	Y (single chair)	1,2,3,4,6,7,9
Knee flexion L	Task swap	60	M	Y (single chair	1,2,3,4,6,9
Lunges	Catch	60	M	Y (dual chair)	1,2,3,4,6,9
Side taps	Follow	60	M	N	1,2,3,4,6,9
Sit to stand	Piano	120	M	N	1,2,3,4,6,7,9
Hip general R	Fire fly	60	M	Y (single chair)	1,2,3,4,6,7,9
Hip general L	Fire fly	60	M	Y (single chair)	2,3,4,6,7,9
Hip frontal flexion R	Forest leaves	60	M	Y (single chair)	1,2,3,4,6,9
Hip frontal flexion L	Forest leaves	60	M	Y (single chair)	1,2,3,4,6,9
Lateral weight shift	Juggar	120	M	N	1,2,3,4,6,9
Side steps	Catch	120	M	N	1,2,3,4,6,9
Side steps	Colour blocks	60	M	N	1,2,3,4,9

15 seconds rest between each game. All participants began on the lowest difficulty level.

Week 4 Schedule:

The difficulty levels was increased from medium to hard for most games, as despite the participants having previously fallen, they appeared to be a high functioning group and were capable. Some games were changed back as participants mentioned they didn't like the gameplay and preferred it to revert back to previous or alternative game (see below). An additional movement was introduced near the end of the schedule as participants were performing the same movement twice over. For this reason, walking was introduced and the exergame was changed to "Izzy the Bee".

Table 4: Mira week 4 schedule displaying characteristics of exergames and movements of SFPC trained

Movement	Game	Duration (s)	Difficulty (E, M, H)	Support provided (Y/N)	Component of the SFPC trained (1-9)
Spine frontal flexion	Fishing	60	M	N	1,3,4,9
Spine lateral flexion	Memory scape	60	M	N	1,3,4,9
Spine general	Airplane	120	M	N	1,3,4,9
Lateral weight shifting	Move	120	M	N	1,3,4,9
Full body turn	Flight control	60	M	N	3,4,6,7,9
Side steps	Nback	120	M	N	1,3,4,6,7,9
Hip abduction R	Animals	60	M	Y (single chair)	3,4,6,7,9
Hip abduction L	Animals	60	M	Y (single chair)	1,2,3,4,6,9
Functional Reach R	Grab	120	M	N	1,2,3,4,6,9
Functional Reach L	Grab	120	M	N	1,2,3,4,6,7,9
Knee flexion R	Task swap	60	M	Y (single chair)	1,2,3,4,6,7,9
Knee flexion L	Task swap	60	M	Y (single chair	1,2,3,4,6,9
Lunges	Catch	60	M	Y (dual chair)	1,2,3,4,6,9
Side taps	Colour clouds	60	M	N	1,2,3,4,6,9
Sit to stand	Power house bid	120	M	N	1,2,3,4,6,7,9
Hip general R	Fire fly	60	M	Y (single chair)	1,2,3,4,6,7,9
Hip general L	Fire fly	60	M	Y (single chair)	2,3,4,6,7,9
Hip frontal flexion R	Forest leaves	60	M	Y (single chair)	1,2,3,4,6,9
Hip frontal flexion L	Forest leaves	60	M	Y (single chair)	1,2,3,4,6,9
Lateral weight shift	Follow	60	M	N	1,2,3,4,6,9
Walking	Izzy the bee	120	M	N	1,2,3,4,6,9
Side steps	Colour blocks	60	M	N	1,2,3,4,9

15 seconds rest between each game. All participants began on the lowest difficulty level.

Week 5 Visit 1 schedule:

P02EX could not manage the lunging exercise and even though they did have a good go for several weeks, they mentioned that it was becoming demoralising. For this reason the game was taken out for them and swapped for hip abduction left and right with the “Piano” exergame. The participant responded well to the change.

Table 5: Mira week 5, visit 1 schedule displaying characteristics of exergames and movements of SFPC trained

Movement	Game	Duration (s)	Difficulty (E, M, H)	Support provided (Y/N)	Component of the SFPC trained (1-9)
Spine frontal flexion	Fishing	60	H	N	1,3,4,9
Spine lateral flexion	Memory scape	60	M	N	1,3,4,9
Spine general	Airplane	120	H	N	1,3,4,9
Lateral weight shifting	Move	120	H	N	1,3,4,9
Full body turn	Flight control	60	M	N	3,4,6,7,9
Side steps	Nback	120	M	N	1,3,4,6,7,9
Hip abduction R	Animals	60	M	Y (single chair)	3,4,6,7,9
Hip abduction L	Animals	60	M	Y (single chair)	1,2,3,4,6,9
Functional Reach R	Grab	120	H	N	1,2,3,4,6,9
Functional Reach L	Grab	120	H	N	1,2,3,4,6,7,9
Knee flexion R	Task swap	60	M	Y (single chair)	1,2,3,4,6,7,9
Knee flexion L	Task swap	60	M	Y (single chair	1,2,3,4,6,9
Lunges	Catch	60	M	Y (dual chair)	1,2,3,4,6,9
Side taps	Colour clouds	60	H	N	1,2,3,4,6,9
Sit to stand	Power house bid	120	M	N	1,2,3,4,6,7,9
Hip general R	Fire fly	60	H	Y (single chair)	1,2,3,4,6,7,9
Hip general L	Fire fly	60	H	Y (single chair)	2,3,4,6,7,9
Hip frontal flexion R	Forest leaves	60	M	Y (single chair)	1,2,3,4,6,9
Hip frontal flexion L	Forest leaves	60	M	Y (single chair)	1,2,3,4,6,9
Lateral weight shift	Follow	60	H	N	1,2,3,4,6,9
Walking	Izzy the bee	120	M	N	1,2,3,4,6,9
Side steps	Colour blocks	60	H	N	1,2,3,4,9

15 seconds rest between each game. All participants began on the lowest difficulty level.

Week 5 Visit 2 schedule:

Movement for game 2 was changed due to the navigation of the cursor during gameplay not performing well. This took a while to understand as it was assumed movement was not conducted correctly, however, we came to realise that it was the cursor being stuck. After changing the movement, participants found the game more enjoyable and permitted more upper body movement.

Table 6: Mira week 5, visit 2 schedule displaying characteristics of exergames and movements of SFPC trained

Movement	Game	Duration (s)	Difficulty (E, M, H)	Support provided (Y/N)	Component of the SFPC trained (1-9)
Spine frontal flexion	Fishing	60	H	N	1,3,4,9
Spine general	Memory scape	60	H	N	1,3,4,9
Spine general	Airplane	120	H	N	1,3,4,9
Lateral weight shifting	Move	120	H	N	1,3,4,9
Full body turn	Flight control	60	M	N	3,4,6,7,9
Side steps	Nback	120	M	N	1,3,4,6,7,9
Hip abduction R	Animals	60	M	Y (single chair)	3,4,6,7,9
Hip abduction L	Animals	60	M	Y (single chair)	1,2,3,4,6,9
Functional Reach R	Grab	120	H	N	1,2,3,4,6,9
Functional Reach L	Grab	120	H	N	1,2,3,4,6,7,9
Knee flexion R	Task swap	60	M	Y (single chair)	1,2,3,4,6,7,9
Knee flexion L	Task swap	60	M	Y (single chair	1,2,3,4,6,9
Lunges	Catch	60	M	Y (dual chair)	1,2,3,4,6,9
Side taps	Colour clouds	60	H	N	1,2,3,4,6,9
Sit to stand	Power house bid	120	M	N	1,2,3,4,6,7,9
Hip general R	Fire fly	60	H	Y (single chair)	1,2,3,4,6,7,9
Hip general L	Fire fly	60	H	Y (single chair)	2,3,4,6,7,9
Hip frontal flexion R	Forest leaves	60	M	Y (single chair)	1,2,3,4,6,9
Hip frontal flexion L	Forest leaves	60	M	Y (single chair)	1,2,3,4,6,9
Lateral weight shift	Follow	60	H	N	1,2,3,4,6,9
Walking	Izzy the bee	120	M	N	1,2,3,4,6,9
Side steps	Colour blocks	60	H	N	1,2,3,4,9

15 seconds rest between each game. All participants began on the lowest difficulty level.

Week 6 Schedule:

The games remained the same as participants reported enjoying this set up. Most games, if not all, were moved up to the hardest level for the final week of training. Participants were considered on an individual level but most were capable using the hardest level for all exergames.

Table 7: Mira week 6 schedule displaying characteristics of exergames and movements of SFPC trained

Movement	Game	Duration (s)	Difficulty (E, M, H)	Support provided (Y/N)	Component of the SFPC trained (1-9)
Spine frontal flexion	Fishing	60	H	N	1,3,4,9
Spine general	Memory scape	60	H	N	1,3,4,9
Spine general	Airplane	120	H	N	1,3,4,9
Lateral weight shifting	Move	120	H	N	1,3,4,9
Full body turn	Flight control	60	H	N	3,4,6,7,9
Side steps	Nback	120	H	N	1,3,4,6,7,9
Hip abduction R	Animals	60	H	Y (single chair)	3,4,6,7,9
Hip abduction L	Animals	60	H	Y (single chair)	1,2,3,4,6,9
Functional Reach R	Grab	120	H	N	1,2,3,4,6,9
Functional Reach L	Grab	120	H	N	1,2,3,4,6,7,9
Knee flexion R	Task swap	60	H	Y (single chair)	1,2,3,4,6,7,9
Knee flexion L	Task swap	60	H	Y (single chair	1,2,3,4,6,9
Lunges	Catch	60	M	Y (dual chair)	1,2,3,4,6,9
Side taps	Colour clouds	60	H	N	1,2,3,4,6,9
Sit to stand	Power house bid	120	H	N	1,2,3,4,6,7,9
Hip general R	Fire fly	60	H	Y (single chair)	1,2,3,4,6,7,9
Hip general L	Fire fly	60	H	Y (single chair)	2,3,4,6,7,9
Hip frontal flexion R	Forest leaves	60	H	Y (single chair)	1,2,3,4,6,9
Hip frontal flexion L	Forest leaves	60	H	Y (single chair)	1,2,3,4,6,9
Lateral weight shift	Follow	60	H	N	1,2,3,4,6,9
Walking	Izzy the bee	120	H	N	1,2,3,4,6,9
Side steps	Colour blocks	60	H	N	1,2,3,4,9

15 seconds rest between each game. All participants began on the lowest difficulty level.

Below is a list of all the movements available to train using Mira and the number of games available to play using the given movement:

Table 8: General list of movements conducted using various games in Mira

No.	Movements	No. of games
1	General – Hip	19
2	General – Spine	19
3	Hip Frontal Flexion	16
4	Knee Extension While Sitting	16
5	Lateral Weight Shifting	14
6	Lunges	14
7	Neck Lateral Flexion	14
8	Proprioception	1
9	Side Steps	14
10	Side Strides	14
11	Spine Frontal Flexion	16
12	Spine Lateral Flexion	14
13	Walking in Place	3
14	Elbow Flexion	16
15	Elbow Flexion in abduction	14
16	Full Body Turn	14
17	Functional Reach	1
18	General Arm	19
19	General Full Body	1
20	General Shoulder	19
21	Hip Abduction	16
22	Knee Flexion	16
23	Shoulder Abduction	16
24	Shoulder External Rotation	14
25	Shoulder External Rotation in abduction	16
26	Shoulder Frontal Flexion	16
27	Shoulder Internal Rotation	14
28	Shoulder Internal Rotation in Abduction	16
29	Shoulder Rotation	14
30	Shoulder Rotation in Abduction	16
31	Side Taps	14
32	Sit to Stand	7
33	Squats	16

Technological drawbacks:

Throughout the six weeks the Mira exergame gave us several issues in tracking the participant correctly. Often the cursor would invert when the participant stepped to one side. This could be an issue when looking at data depending if the data for the left or right side is logged incorrectly (E.g. right ankle data for left ankle). The exergame often froze during the movement or the game tutorials. This would involve restarting the session and continuing from that exergame again. This was observed as rather demotivating for participants as they were often discouraged and blamed themselves for these issues. As I was present for each session, I informed them that this was not their fault. Participants were encouraged to only use support if they really needed to and the support was made available for the whole of the game where shown. Only one participant actively tried to not use the support (P08EX) where other found themselves using the support more frequently.

9.14 Appendix N - Course overview of the Staying Steady programme

Aspect	Weeks 1-2	Weeks 3-8	Weeks 9-14	Weeks 15-20
Summary	Mainly Seated, focusing on technique and safety.	Progression to standing, basic exercises, with gradual progression to dynamic.	Dynamic, introduce floor work	Circuit based exercises with separate floor work element. May also include taster sessions of local exercise classes e.g. Tai Chi or Gym.
Warm – Up	10-15 mins seated - Posture check, Circulation booster, mobility, rewarm.	Progress to standing - Posture check, Circulation booster, mobility, rewarm.	All in standing - Posture check, Circulation booster, mobility, rewarm.	In Circuit - Posture check, Circulation booster, mobility, rewarm.
CV	10 mins seated—Marching, toe taps, canoeing, widebased sway, side step, lunge, fartlek marching	Progress to standing—Marching, toe taps, canoeing, widebased sway with claps, side step, lunge, fartlek marching	All in standing, adding more arms—Marching, toe taps, canoeing, widebased sway with claps, double side step, fartlek marching	In Circuit - Walking in circle, add arms and larger stepping movements, side steps, as weeks progress.
Balance	10 mins standing—Sit to stand, Knee bends, hip abductors, heel raises, toe raises, tandem stand, one legged stand.	Standing, progress to dynamic—Sit to stand, hip abductors, toe walking, heel walking , tandem walking, flamingo swing, sideways walking, backwards walking, Obstacle course (basic) - stepping over objects, picking up objects	Standing, dynamic—Backwards walking, tandem walk, backwards tandem walk, compensatory stepping (front, side and back lunges). Obstacle course (increase level) - walking and turning, stepping over, picking up objects, reaching up, step up.	In Circuit—Stepping over objects, step up, picking up objects, reaching up.
Strength	10 mins seated, all theraband—Leg press, ankle strengthener, hip strengthener, upper back, arm curl, tricep backward press, chest press, wrist strengthener,	Progress to dynamic—As before, also introduce stride knee bends, wall press, knee bends.	As before—increase band strength and repetitions.	In circuit—Exercises as before, ensure high resistance.
Floor Work	5 mins—Demonstration only	Backward chaining and gradually introduce transitions and functional moves.	As before, but introduce floor exercises for strength, wrist bone load, back leg lifts, back strength, hip strength.	As before, not to be part of the circuit, can add stretches.

Cool Down	10-15 mins seated—Circulation lowerer, stretches (15-20 seconds) Tai Chi (rowing the oar)	Progress to standing—Circulation lowerer, stretches (15-20 seconds) Tai Chi (rowing the oar/ clouds)	In standing—Circulation lowerer, stretches (15-20 seconds) Tai Chi , progress to dynamic (rowing the oar/clouds)	In standing—Circulation lowerer, stretches (15-20 seconds) Tai Chi, dynamic (rowing the oar / clouds)

9.15 Appendix O

Staying Steady Educational information sheets

Topics

Week 1 - About Staying Steady
Weeks 2&11 - Dealing with a fall
Weeks 3&12 - Fitter feet & footwear
Weeks 4&13 - Home safety
Weeks 5&14 - Medication & side effects
Weeks 6&15 - Nutrition, hydration & alcohol
Weeks 7&16 - Bone health
Weeks 8&17 - Eyesight and hearing
Weeks 9&18 - Staying safe when out and about
Weeks 10&19 - Keeping active
Week 20 – What's next?

About Staying Steady

- 20 week progressive programme of evidence based exercises
- One hours exercise including warm up, stamina, strength, balance and functional work followed by a cool down
- Each session is followed by education session and a chat
- First and last weeks will consist of assessments to capture confidence, wellbeing and physical scores so that we can compare before and after scores – this helps us to secure future funding.
- Classes are FREE (but donations are welcome)
- Home Exercises are an important part of the programme – everyone will be provided with a guide and a theraband.
- Classes aim to improve strength and balance and increase confidence and at the end of the programme participants are encouraged to continue with exercise. The instructor will support you participants with seeking local options.

Dealing with a fall – "I cant get up"

It is important to have a plan in place in the event of a fall.

"I cant get up"

- Attract attention – shout or bang on something (e.g. banging a walking stick against a radiator)
- Press your pendant alarm or use the telephone of you can – if you have a mobile phone, try to keep it with you at all times
- Can I get warm and comfortable? – Find something soft and warm nearby such as cushions, towels, blankets, clothes or even a rug. Is it possible to access food in lower down kitchen cupboards?
- Can I keep moving? – Moving position will help to avoid pressure ulcers. Moving joints will help with circulation and reduce joint stiffness. Try to roll away from damp areas if you pass urine.

Dealing with a fall – "I can get up"

It is important to have a plan in place in the event of a fall.

"I can get up"

- Ease yourself up onto your elbows in 'side sit' position
- Try to remain calm and look for a piece of sturdy furniture (approximately knee height) to help you up. Remember that you do not have to get up in the same place that you have fallen and you may have to crawl, roll or shuffle towards the piece of furniture you have chosen to help you up
- Remember that you can pull cushions or pillows onto the floor to increase comfort when trying to get up from the floor
- Complete backward chaining method

Fitter feet

Looking after your feet

- See your GP if you have painful, swollen or tingling feet
- Trim toenails regularly and keep feet well moisturised to avoid painful cracking
- Use a pumice stone on hard skin and if foot care is becoming difficult, see a podiatrist.

Footwear

Footwear

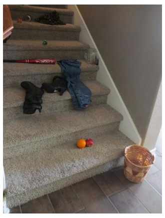
- Soles should be thin enough to 'read' the ground but have enough cushioning for shock-absorption, as well as a good tread for gripping.
- Any heels should be low and broad for maximum stability
- Choose round or square toed shoes to give toes more space. They should be long enough so that your toes do not touch the end but offer support around the middle part of the foot
- Go for shoes with fastenings such as laces or Velcro, as they can be adjusted for comfort
- Say goodbye to old work out slippers. Slippers should fasten, stay on and provide good grip.
- Never walk on hard floors in socks or tights – wear your slippers instead.

Home safety

Lighting – Did you know that 60 year old eyes need three times as much light as a 20 year old? Ensure that all rooms in your home have effective lighting. Consider two-way switches on the landing or along hallways to avoid having to pass through these areas in the dark. Never walk around in the dark, if you regularly get up for the loo at night, keep the landing light on or use a nightlight.

Heating – Make sure that your home is adequately heated. If you are cold your joints can become stiff. An ideal temperature for your home is 21 degrees Celsius, apart from your bedroom which should be slightly cooler at 18 degrees Celsius. There are local services which can help you to make improvements in the home to save money on energy bills and there are grants available too.

Living Areas – The most common causes of falling in the home include tripping over loose carpets and rugs, clutter and loose cables. Consider removing rugs or ensuring that they have non-slip underlay. Replace or tack down frayed carpets and remove any clutter, especially in the hall, landing, doorways or stairs. Cables and wires can be cable tied or tapes onto the wall or skirting boards. If you have pets, consider buying them a bright collar with a bell.

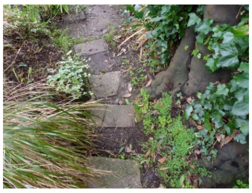


Home safety

Kitchen / Bathroom – Consider installing grab rails in the bathroom and always use a non-slip mat in the bath or shower. Clear up any spills straight away so you don't slip on them later. If you feel as though you are always reaching up for things in high shelves, consider rearranging cupboards so that commonly used items are lower down.

Garden – Keep paths free of moss and leaves and trim back any overhanging branches near to footpaths. Repair any cracks in the paving. Consider installing a grab rail at the front and back door or install safety rails on your steps.

You can contact Tyne and Wear Fire and Rescue Service for a FREE Home Safety Check – 0800 0327777



Medication and side effects

- The older we get, the more likely we are to be prescribed medications for health conditions
- Some common side affects include dizziness, drop in blood pressure when standing up and sleepiness, all of which can contribute to a fall
- Never stop taking prescribed medications suddenly, however if you are experiencing any side effects it is important to contact your GP to see if the medication can be adjusted
- Ask your GP to review your medication every 12 months (every 6 months if you are over 75 and taking more than 4 or more medications)
- Be wary of alcohol intake, as the alcohol may interact with prescribed medications and bring about unwanted side effects

Nutrition

Nutrition – It is important to get a balanced diet containing carbohydrates, fats, proteins and vitamins and minerals. For strong bones, Vitamin D, Calcium and Protein are important!

- Vitamin D

Fatty fish like tuna, mackerel and salmon. Also cheese and egg yolks. You also get vitamin D from the Sun!

- Calcium

Dairy products such as milk, cheese and yoghurt. Also green veg like spinach, kale and okra. Beans are also a good source of calcium as are some types of fish (sardines, salmon and rainbow trout).

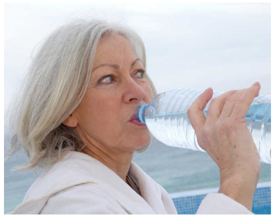
- Protein

High protein foods include meat, fish, cheese, tofu, beans, lentils, yogurt, eggs, nuts, and seeds.

Hydration

Hydration

- Staying hydrated is crucial for keeping the systems of the body working as well as they can. It helps to regulate blood pressure, temperature as well as helping with bowel movements.
- Water also helps to protect and cushion joints and vital organs and helps the body to absorb nutrients.
- Staying hydrated is also important for the brain, as it helps you to stay alert and helps with concentration (75% of the brain is made up of water).
- There are also many risks to becoming dehydrated including falling, kidney problems, UTI's, pressure ulcers, confusion and hyperthermia.
- Drink plenty of fluids such as water, diluted squash or fruit juice. These hydrate you better than tea or coffee, as the caffeine in tea and coffee can cause you to pass water more quickly.
- Take extra care in warm weather or after exercise, as you lose more water through sweating.



Alcohol

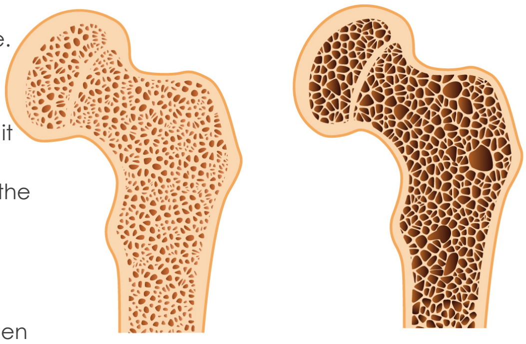
Alcohol

- As we get older, we often feel the effects of alcohol more than we did when we are younger.
- Drinking the same amounts of alcohol as when you were younger often results in a higher blood alcohol concentration due to having less muscle and more body fat (alcohol is not drawn into body fat as well as it is to muscle so stays in the blood).
- Older people are therefore likely to experience unsteadiness after drinking alcohol, which may lead to a fall.

Bone health - Osteoporosis

Osteoporosis

- This is where bones become thinner and more fragile.
- Exercise does not need to be vigorous; everyday activities such as walking are beneficial.
- Any weight bearing exercise program is effective as it encourages an increase in bone density.
- Bones become stronger due to the pulling forces of the muscles on the bone. Without this action, bone loses calcium faster than it can be replaced.
- Vitamin D, Calcium and Protein should be increased within your diet.
- Osteoporosis is more common in females, as oestrogen level significantly fall during menopause.



Healthy bone Osteoporosis

Bone health - Arthritis

Arthritis

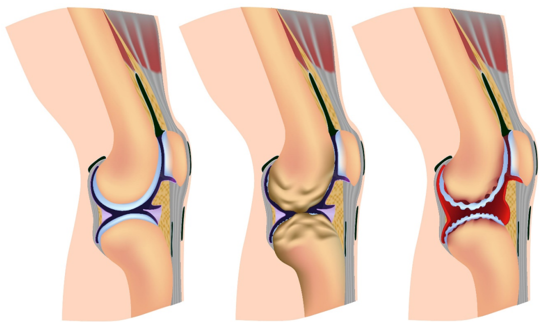
The two most common types of arthritis are Osteoatrhritis and Rheumatiod Arthritis.

Osteoarthritis:

- Cartilage lining starts to roughen and thin out
- Thicker synovial fluid and decreased availability of it increases stiffness of joints.
- Start with gentle mobility exercises to warm up the joints.

Rheumatiod Arthritis:

- Less common than osteoarthritis
- Immune system targets affected joints, leading to pain and swelling
- Start with mobility exercises to warm up the joints, but avoid exercising when experiencing a flare up.



Healthy Joint Osteoarthritis Rheumatoid Arthritis

Eyesight

Vision changes can increase your risk of falling. Having your vision checked regularly, and looking after your glasses, can help to prevent a fall.

Common eyesight problems associated with ageing include long-sightedness, contrast sensitivity and problems with depth perception. These issues can cause problems when stepping off curbs or changing walking surfaces. There are also some common eye problems that can be caused or made worse through other long term conditions such as diabetes.

- Have your eyes checked regularly (once a year if you are aged 60+)
- If you need glasses, look after them and check your prescription regularly
- Bifocals or varifocals can make things appear closer than they are if you are looking through the wrong part of the lens and can cause problems when walking up or downstairs or stepping on or off a curb.
- If you have difficulty getting to the opticians, the NHS may be able to provide a home eye test – 0800224488

Hearing

Hearing changes can increase your risk of falling. Having your hearing checked regularly, and looking after your hearing aid, can help to prevent a fall.

Problems with hearing can affect the balance centre in your inner ear, and your awareness of hazards in your environment, making tripping and falling more likely. If you've noticed a change in your hearing, speak to your GP as soon as possible.

If you suffer from hearing loss, hearing aids are available free on the NHS and can help restore some, if not all, of your hearing.

Staying safe when out and about

In the street:

- Take your time and don't rush.
- Be sure to scan for hazards, looking a few feet ahead will allow for you to see cracked pavements, obstacles and uneven surfaces before you get there.
- Shopping bags can obstruct your view. Consider using a rucksack for small amounts of shopping – it is better for your back too!
- When shopping be careful for lipped door frames and be careful when stepping out into bright light, as eyes may need time to adjust.
- Watch out for subtle changes of gradient, especially near pedestrian crossings.

Staying safe when out and about

On the bus:

- Keep your bus pass or money near to hand so that you don't have to root round for it when getting on the bus. This way you have a better chance of boarding safely.
- Don't be afraid of asking the driver to wait until you seated before moving off.
- Carry a Bridge Card – these are free from Nexus and inform the driver that you need additional support when boarding the bus. The driver may lower the step, count change and wait until you have sat down before moving off.

Walking Aids:

- Don't be embarrassed to use a walking aid if it helps you to stay steady. They are a lot more popular than you realise.
- Make sure your stick is the right length – it should be level wit your wrist crease when your arm is down by your side and there should be a rubber ferrule at the bottom which you should replace before it has worn.
- If a stick is no longer quite enough, talk to your physiotherapist about getting a rollator or walking frame.

9.16 Appendix P

7 Day Activity Data - Participant Instruction to reattach a tracking device

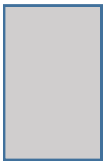
Reattach the device carefully and thoroughly (on completely dry skin using new tape provided to you)

Use the recording sheet provided (next page)

- Mark the skin with a marker and attach the device on the skin above Lumbar Vertebrate number 5 (centre of the back just above the belt line)
- Secure the tracker to the skin with a single PALstickie and cover it by making a cross shape with two pieces of Hypafix in the order shown below:

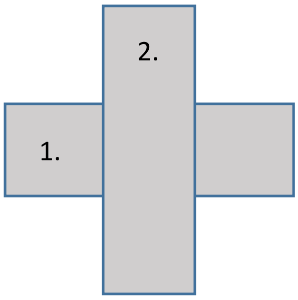
Tracker

1.



PALstickie

2.



Hypafix

3.

- Place the tracker device **ALWAYS** in the same orientation as shown, Figure 1 below, the **port and the arrow must always face downwards and the numbers should always face away from the skin**

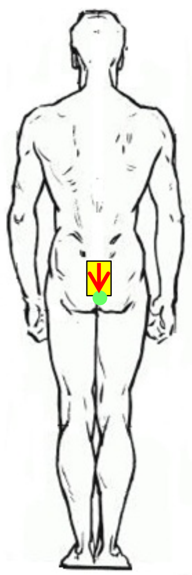


Figure 1: Schematic demonstrating the positioning and orientation of the tracker sensor

Initial set up to be done by a member of the research team in the lab on the assessment visit.

Date & time of attachment:

Date: ________________

Time: ________________

Date & time of removal:

Date: ________________

Time: ________________

Attachment Height (cm):

Wearing the activity monitor:

You must keep the activity monitor worn **at all times** for the full period of **7 days (including at night)**

It should only be removed if:

1. Partaking in any water based activity/sports, e.g. swimming, sauna, etc.
   Important: If the activity monitor becomes uncomfortable to wear and/or causes irritation to the skin, call the study investigator immediately.

Note:

- There are no switches/buttons on the device; it will remain 'ON' for the full duration.
- The Device is **PARTIALLY** waterproof and **CANNOT** be worn whilst bathing but can be worn whilst showering so, please remove to have a bath and replace once skin is completely dry using new tape provided.
- Please try to wear the device at all times, including at night, for the full 7 days.
- On the 7th day, you will wear it as you come back for your next visit whereby a member of the research team will take it off for you.

If you have any problems please contact: Robin Tahmosybayat on 07476013393 or alternatively via email at: robin.a.tahmosybayat@northumbria.ac.uk

If the activity monitor is removed by you, for the reasons outlined above and you need to reattach it, it must be attached exactly like it was before by the study investigator.

Tracker came off/ was removed	Date	Time	Tracker reattachment	Date	Time

NOTE IF ANY TRIPS OR FALLS OCCURED DURING THE 7 DAY PERIOD:

9.17 Appendix Q

COREQ (COnsolidated criteria for REporting Qualitative research) Checklist

A checklist of items that should be included in reports of qualitative research. You must report the page number in your manuscript where you consider each of the items listed in this checklist. If you have not included this information, either revise your manuscript accordingly before submitting or note N/A.

Topic	Item No.	Guide Questions/Description	Reported on Page No.
Domain 1: Research team and reflexivity			
Personal characteristics			
Interviewer/facilitator	1	Which author/s conducted the interview or focus group?	201
Credentials	2	What were the researcher's credentials? E.g. PhD, MD	201
Occupation	3	What was their occupation at the time of the study?	201
Gender	4	Was the researcher male or female?	201
Experience and training	5	What experience or training did the researcher have?	201
Relationship with participants			
Relationship established	6	Was a relationship established prior to study commencement?	201-202
Participant knowledge of the interviewer	7	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	201-202
Interviewer characteristics	8	What characteristics were reported about the inter viewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	201-202
Domain 2: Study design			
Theoretical framework			
Methodological orientation and Theory	9	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	205
Participant selection			
Sampling	10	How were participants selected? e.g. purposive, convenience, consecutive, snowball	203
Method of approach	11	How were participants approached? e.g. face-to-face, telephone, mail, email	203
Sample size	12	How many participants were in the study?	202
Non-participation	13	How many people refused to participate or dropped out? Reasons?	N/A
Setting			
Setting of data collection	14	Where was the data collected? e.g. home, clinic, workplace	203
Presence of non-participants	15	Was anyone else present besides the participants and researchers?	203
Description of sample	16	What are the important characteristics of the sample? e.g. demographic	202

		data, date	
Data collection			
Interview guide	17	Were questions, prompts, guides provided by the authors? Was it pilot tested?	203-205
Repeat interviews	18	Were repeat inter views carried out? If yes, how many?	205
Audio/visual recording	19	Did the research use audio or visual recording to collect the data?	203
Field notes	20	Were field notes made during and/or after the inter view or focus group?	203
Duration	21	What was the duration of the inter views or focus group?	
Data saturation	22	Was data saturation discussed?	203
Transcripts returned	23	Were transcripts returned to participants for comment and/or	205
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Developed from: Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*. 2007. Volume 19, Number 6: pp. 349 – 357

Once you have completed this checklist, please save a copy and upload it as part of your submission. DO NOT include this checklist as part of the main manuscript document. It must be uploaded as a separate file.

9.18 Appendix R

Interview transcripts

Interview 1

Interviewer/Transcriber - Robin Tahmosybayat

Participants: P01EX

Loctation: Northumbria University Biomechanics Lab in Sport Central.

Time: 20 minutes

Interviewer: Ok so this is participant number one, exergaming group interview.

Q.1.What are your thoughts on the training program? Did you enjoy it?

Interviewer
So what are your thoughts on the training programme? Did you enjoy it?

P01EX
I did enjoy it very much.

Interviewer
Brilliant.

P01EX
Um, not quite sure what to expect in the beginning but as the weeks went on I got more comfortable with it and um, definitely felt like I was exercising but I enjoyed it and that was the big plus for me.

Interviewer
Right ok so normally you don't exercise for enjoyment or you just see it as something necessary?

P01EX
I do it because I feel I should, the age I am and everything that you read in the press and health. I do it because I think it's necessary. I don't always want to do it but I didn't have a problem with this at all.

Q.2. Anything specific that stood out about the training program? (Favourite game? Favourite movement?)

Interviewer
Ok brilliant. So anything in particular that stood out about the programme? So the fact that you…

P01EX
Yes I didn't feel like it was exercise, I think it was just a bit of fun and also given again, going on about age, I felt I was using my brain a little bit just to, coordination, um, I had to think about what I was doing as well to get the games to work, which I enjoyed that. I wasn't very good at it haha

Interviewer
Well you say that but you were

P01EX
But I enjoyed it, I did, I did enjoy that.

Interviewer
Ok great. And so, um, obviously there were some drawbacks to the games with just technology but that's inevitable.

P01EX
I suppose you're always going to have that, aren't you.

Interviewer
Yes, and it's just um.

P01EX
But it seemed to even out, it seemed to

Interviewer
Yes. So the majority of the time it tends to work,

P01EX

It did work yes

Q.3. How do you feel after a particular session during the training program?

Interviewer
Just a couple of moments really wasn't it. Ok and so after a particular session. Like so it could be the first it could be the fifth, it could be the last one. Um would you… would you actually, um, like did you feel, not just that you had exercised but how did you feel in general?

P01EX
Um, yea I think I was putting more effort in towards. I personally thought I was putting more effort in as the weeks went on.

Interviewer
Ok

P01EX
Um, but I could see a benefit in other exercise that I did. I think I mentioned about me normally having problems with the knee.

Interviewer
Yes. Yea you did say that yea.

P01EX
Um and you explaining as well, which, you know, how, the right posture for the exercise

Interviewer
Yes. That was helping as well?

P01EX
That was helping. That seemed to help.

Q.4. Any aches or pains that have gone away? Have come back?

Interviewer
So you mentioned briefly just then about the knee. Was that, you had knee pain at the start?

P01EX
I do get knee pain if I go up and down stairs a lot and when I do certain exercises, bending exercises, you know, yoga positions things like that.

Interviewer
Ok.

P01EX
And um in another lot of exercise that am I now doing, it definitely helped.

Interviewer
Right ok.

P01EX
I was there, where are we, I was there on Monday and it helped.

Interviewer
Yea? It helped as well.

P01EX
Sorry not today but last Monday.

Interviewer
Ok, well that is good to know.

P01EX
Yea definitely. There has been a definite improvement.

Interviewer
Fantastic so the knee pain, is it muscular?

P01EX
I am just assuming its arthritis. I don't know.

Interviewer
Arthritis. Sort of achy sort of pain. Well that was my next question. Any aches or pains that have gone away, have come back? So you have answered that.

P01EX

Yes yes.

Interviewer
Um, it would be great to hear, at the next assessment point if that pain started to come back because you stopped doing this training. Um so that is something for you to kind of have a think about, to kind of notice to see if it does. Don't try haha so you're not going to try.

P01EX
No no haha

Interviewer
Ok um, so yea you mentioned that you have been doing some other types of training as well so I mean in general would you say you do exercise to stay healthy and keep fit.

P01EX
I try to I mean I must admit, depending on what's happening with work and home. Some weeks and months I do more than others.

Interviewer
Yep.

P01EX
Um, but more recently I have been trying to get back into it so… yea.

Q.5. How does this compare to other types of training programs you have been a part of?

Interviewer
And how would you say that this (exergaming) compared to other types of exercise. I know we have mentioned briefly about it.

P01EX
For me personally, it was more… what we did here was more enjoyable because it was more like a game.

Interviewer
Right ok.

P01EX
And… I mean I don't think I am a competitive person but maybe I am and I wanted to improve haha

Interviewer
See so you'd say a little bit haha

P01EX
I always said I want... haha

Interviewer
haha little bit

P01EX
I wanted to improve week on week.

Interviewer
Yea

P01EX
I was trying to get better at it.

Interviewer
Right ok. I see but that's like er, it's almost like that an internal motivation isn't it?

P01EX
Yes

Interviewer
It's internal competitiveness with yourself.

P01EX
But the fact that you've got the countdown, you've got the figures on the screen, which you haven't got in other types of exercise. See I think that was making me more aware of it.

Interviewer
As in like yea so you know you've got a certain amount of time to do

P01EX

Yea you've got the countdown, you've got the … yea you've got the set number of minutes

Interviewer
Yea

P01EX
And then you. There was that score at the end of each session. You wouldn't have…

Interviewer
Yes and so that… how would you feel if you were doing it and there wasn't the score?

P01EX
I think as long as I was enjoying it I wouldn't be bothered.

Interviewer
Yea you wouldn't be as … but it's just something extra, you get something at the end.

P01EX
Yea yea. Yes exactly. You felt like you were doing ok.

Interviewer
Great um, so have you done any balance training programmes before?

P01EX
No.

Interviewer
No. Nothing specific.

P01EX
Well yoga, but I haven't actually done yoga on a regular basis for a very long time.

Interviewer
Right ok. Um. So in yoga when you have done yoga or in some of the classes that you have gone to, when they use… when they do the movements, are you aware in the class that you are doing specific movements or are you just focused on maybe the instructor or?

P01EX
Bit of both I would say

Interviewer
Right, yep.

P01EX
Um… and balance comes into it, definitely

Interviewer
Right ok.

P01EX
Yea.

Q.7. Would you do it again?

Interviewer
Ok. Would you… If you had the option to come and do it again, would you?

P01EX
Yes definitely

Q.8. What would you change about training program (Exergaming, Staying Steady) console, game) to make it more engaging?

Interviewer
Yes brilliant. Um and if there's something that you would change about the programme, would it be the console? The games? Maybe to make it more engaging…

P01EX
Um… it's hard to say I mean obviously only over six weeks, if you were using it at home permanently you would want a bit of a mix up wouldn't you, you'd maybe want different types of games. You would want to be able to change the games or the …

Interviewer
Yea. Which you could

P01EX
Which you could.

Interviewer
If you had it at home, you could do that.

P01EX
Um, other than that I can't think of anything, I mean, you were the one who was setting it all up.

Interviewer
Yes.

P01EX
So you have got that aspect of it as well haven't you.

Interviewer
Yes so if you had the responsibility to set it up by yourself

P01EX
To set it up

Interviewer
You'd be able to choose the movements you wanted,

P01EX
Yes

Interviewer
You'd be able to choose the movements… uh, the games that you preferred

P01EX
Yes

Interviewer
I mean I know there was definitely some games that people preferred more than others

P01EX
Others yes.

Interviewer
But, all in all it wasn't a massive difference between them though

P01EX
No no.

Interviewer
Was it or?

P01EX
Um… firstly there was only… one that I'd struggled with but that's because I wasn't very good at it.

Interviewer
Right

P01EX
So naturally you're going to go towards the ones that you can do.

Interviewer
Yes.

P01EX
Um, but no I wouldn't have said so and it was… you were exercising all different types of… you know, parts of your body

Interviewer
Yes. Yea yea

P01EX
So no no.

Q.9. What are your perceptions on safety of using this method (Exergaming/ Staying Steady) to train balance? (Self-efficacy) Were you anxious at all during training? (Anxiety)

Interviewer

Ok… brilliant. Um and in terms of safety. What were your perceptions on safety of using this method to train balance? So exergaming to train balance…

P01EX
Um… it was quite safe.

Interviewer
Like did you feel for example like did you feel like the environment was safe enough?

P01EX
Oh yes.

Interviewer
Did you feel the movements you were doing were safe enough or would be safe enough?

P01EX
Yes I think so because you're only going to do what you can do.

Interviewer
Yes

P01EX
I would have thought. Um…

Interviewer
Yep. But at no point was the game trying to push you beyond your limits?

P01EX
No. no.

Interviewer
Ok. Did you feel self-conscious at all when you were doing training?

P01EX
I did at the beginning.

Interviewer
Yea. Is that because it was a new concept and new people and new environment?

P01EX
Yes something I had never done before. Yes absol… whole mixture.

Interviewer
But then did that dissipate quickly?

P01EX
Oh yea. First week and then I mean, you know.

Interviewer
And then once you get into it yea haha

P01EX
I kept coming back haha

Q.10. Were you conscious of the movements being conducted during your training session? Where was your attention? Did you enjoy the experience? Worried about performance? Did you feel in control?

Interviewer
Ok, brilliant, um so yea like we just said before about the… being conscious of the movements in the other exercise class. Were you conscious of the movements you were doing here?

P01EX
Not as much no.

Interviewer
If you try and picture yourself

P01EX
Yes

Interviewer
In the game situation where you have just done the calibration, you're going into the first game, yes it shows you the movement you need to do but actually during the game are you aware of the movements?

P01EX
No no. I don't think I was

Interviewer
Or do you think you were focusing elsewhere?

P01EX
I think you're focusing so much on… on getting it done in the time that you've got.

Interviewer
Yep.

P01EX
I would say not. No. Less conscious I would say.

Interviewer
Right ok.

P01EX
Because if you are in a room full of people.

Interviewer
Yep

P01EX
You want to do it right don't you. Kind of thing…

Interviewer
As in you're aware that people are watching you? Or…?

P01EX
Watch you. Where you've got that added fear.

Interviewer
So you don't have that but that's what you'd have in a group class

P01EX
Yea.

Interviewer
Ah ok, that's an interesting point actually

P01EX
Do you know what I mean? A lot of people don't exercise. Especially women…

Interviewer
Yea because a lot of people don't think that. I mean I would never have thought that. Yea yea.

P01EX
They wouldn't go to a class but something like that they would do you see.

Interviewer
They would do at home and it would still keep them interested. That's a really good point. So yea it can almost work in favour, not necessarily self-consciousness.

P01EX
Um hm.

Interviewer
You could feel like a class-based self-consciousness whereas with that, those types of people that would feel that (Class-based exercise) would feel more confident using this (Exergaming) maybe and less self-conscious.

P01EX
Yes. I think so yes.

Interviewer
Um yea ok

P01EX
I remember my children having the Wii game and um there was all sorts of bits and that, we used to put it on. I have to be honest, I wasn't interested in that at all but that (Mira) is different somehow.

Interviewer
Right, Something about the Wii?

P01EX

I don't know, it just flowed more. Something about the Wii was just… I maybe could of done it once in a while but I think I would stick with that, whereas, maybe the Wii's changed I mean it's a long time since… I don't know what the games are now but certainly going back to when they first came out

Interviewer
Yep.

P01EX
It didn't… I wouldn't want to use it regularly.

Interviewer
Regularly, ok… and so really… what stands out about Mira that didn't stand out bout the Wii?

P01EX
I think it was fun. I know the Wii is supposed to be fun but I just found it quite tedious. I'm trying to think of the games we had on it… there was golf and there was a dancing one but not exercise

Interviewer
Right ok.

P01EX
Whereas I felt like I was actually …

Interviewer
More targeted

P01EX
Doing something with that yea

Interviewer
Ok but bearing in mind as well that the Wii was.. the Wii is a family game but its aimed probably at the younger age upwards but this game has started at the other end and worked backwards.

P01EX
Yes yes.

Q.11. How do you feel the training program impacted your level of fatigue? How did this impact your motivation to train?

Interviewer
Um, yes so and how did you feel that the, I mean the whole six weeks? After each individual session? How did you feel that impacted your levels of fatigue?

P01EX
I would say it improved it…

Interviewer
Yea

P01EX
Because doing the other classes I could see an improvement and I know that wasn't to do with the class because I was hardly going to the other one.

Interviewer
Right yea.

P01EX
And just generally… activity levels are totally…

Interviewer
Are totally? Are they higher you say?

P01EX
Well I would say so yes.

Interviewer
And does this impact your motivation to do exercise do you think?

P01EX
Yea if I can see a benefit

Interviewer
If you can see a benefit

P01EX

Because that's the trouble isn't it, especially when you're older,

Interviewer
Hmm if you don't want to waste time doing things

P01EX
Yea well you know, is it really going to make that much difference but I think it yea, I think that can.

Interviewer
Great. Yep. I um I like hearing that. That's great. haha

P01EX
haha

Interviewer
It's interesting to know that sometimes you say… well you used to… you were saying you can feel it that you have been worked in the session. I remember a few times where you had said that and then but yea you had not really noticed the movements during the training so you're doing training but you're not really noticing because you're just playing the game essentially, that's where your focus is but then you would come away after the session and say 'I feel like I have been worked' so you are still getting the exercise in but its just that you're not really seeing.. its not really awareness in the moment of it.

P01EX
No that's right.

Interviewer
And so that way if you were to carry on training like that you will notice that your fatigue will improve but you're not actually noticing it at the time.

P01EX
No. No. That's right.

Q.12. Did the training program feel negative in any way in terms of your self-thoughts? (Negative self-talk) Did you feel absent during the program? Could you sleep ok? Slowness of thoughts? Angry?

Interviewer
I see. Um so would you say the training programme gave any negativity at all… like was there anything negative about the programme, um, about your self-thoughts, your personal thoughts.

P01EX
I suppose just the fact that, right, personal thoughts

Interviewer
Or at any point did you feel like absent from the programme or?

P01EX
Some of the games, well I mean we're talking about concentration. I struggled with some of them to really keep concentrating, but that's again…

Interviewer
But that's like as in concentration, not like feeling fed up with it as in your mind going elsewhere

P01EX
No no just I couldn't keep that level of concentration up in what I was doing. Um, not really.

Interviewer
Any frustrations, any anger?

P01EX
No no I wouldn't have said so

Interviewer
No sad thoughts at all or anything?

P01EX
No no. I mean I would have liked to have been better at it haha

Interviewer
Yea but I mean it's not something… would you…

P01EX
I wouldn't worry about it, no. It wouldn't make me go away and feel more negative if I'd done it no no definitely not no

Interviewer

Ok so mainly feelings of positive

P01EX
I would say so yea.

Q.13. Can you tell me how you feel when you go about everyday activities? Are there any fearful moments you have or concerns when you are out and about? (falling over)

Interviewer
Ok so in that case, now that you go about your everyday activities, I know we have stopped the training now but if you were to go about your daily activities would you feel more confident in getting around? Like a slope? Or going upstairs? Going downstairs? You mentioned the knee pain you get going upstairs. Would you have any fear of falling over when you are going about your everyday activities? Like from before the training programme until now essentially.

P01EX
I would say… the fear of falling hasn't changed if I'm honest because the periods been too short. There's obviously been an improvement in whatever is happening in my knee whether its, I don't know, ligament or arthritis or whatever. But if I'm honest I wouldn't say… because I do have a fear of falling.

Interviewer
Right yea, in any particular circumstances?

P01EX
Icy, I hate the winter, I dread the winter because they don't grit the pavements anymore. Sometimes if I'm out with the dog, he's a strong dog and he can pull me over. Just because I have injured myself before.

Interviewer
Right so is that because you fallen once is it?

P01EX
Yes yes, I went through a phase in my mid-fifties maybe of… just it was clumsiness probably. I don't know what it was but I did fall a few times and it really… it really does kind of make you a bit more cautious.

Interviewer
Ok.

P01EX
If I can give you an example I was walking in the lake district not last Saturday gone but the weekend before and I was slow. I can do it but I was slow coming down because I was terrified of falling.

Interviewer
Are these mossy rocks or are we talking like grass and…

P01EX
Yes just a path kind of just outside of Keswick and I was really scared. Physically I could do it, picking my way down but I was very slow.

Interviewer
But that's again you know, that's a high functioning activity still. Out and about rambling is different to walking around the house, for example.

P01EX
True. True.

Interviewer
So would you say the fear of falling is maybe different depending on the type of activities you're doing?

P01EX
I suppose it is yea. Yea that's true yea.

Q.14. How confident are you that you will not lose your balance or become unsteady in everyday outdoor and indoor activities now that you have received some balance training? E.g. Up and down stairs? Standing on a high surface? Escalator in shopping mall? Quick turning?

Interviewer
Yea so this is a very similar question in a way, but instead of the fear of falling over its more balance confidence so you've got everyday activities in the house, commuting to work or out and about wherever you're going, walking the dog like you said and so now that you have received some more balance training, would you say that there is a change in any of those balance confidence levels in any particular activity?

P01EX

Well certainly in the Zumba class like I said.

Interviewer
So in your other exercise classes you feel more confident in your balance?

P01EX
I definitely feel more confident yes.

Interviewer
Brilliant. You said you had fear. I mean the fear's not gone. The fear of falling over hasn't gone.

P01EX
It hasn't unfortunately, I mean no different.

Interviewer
Any kind of reducing in it? Yes you have still got the fear, but you also maybe have some prompts to tell yourself now when you are because of any sort of things you were doing in here that would remind you "oh I am standing on one leg"

P01EX
Yes I suppose… yes definitely I think when you were telling me the, I don't know if it was to do with the game, certainly in the session you were telling me how to put my leg at one point and you know where to put the… how to stand properly. That kind of stayed, has stayed with me a little bit.

Q.15. Is there anything else that this training has done for you that you would like to comment on?

Interviewer
But that's more so what I was saying as opposed to onscreen tutorials. Ok well that's good to know. Is there anything else you have enjoyed? Anything else you want to comment on?

P01EX
I've just really enjoyed taking part and I think it's a great bit of research that you are doing. I think obviously I keep going on about the age thing but for me that's where it's at because I don't want to end up in a wheelchair. I don't want to end up with osteoporosis. I want to keep active as long as I can. I have really enjoyed it.

Interviewer
Ok if there was, I mean I don't know how much this would cost to have one of these in the house. It might be quite expensive for an individual to buy but if it was set up at a research centre where you had a point of contact where you would have an appointment. Someone would be contacting you to make appointments to go there regularly, like you would in an exercise class.

P01EX
You would maybe hire room, definitely.

Interviewer
You could hire a room where this (Mira) is set up. Do you think you would go? Would you stick to appointments to go there? Maybe… you know it would be something that would be part of your week.

P01EX

If it was scheduled in, absolutely.

Interviewer

And even if you wanted to take people to watch to show them to have a go or arrange an hour where you will all just hop on and hop off and just keep having a go and stuff like that, you would do it?

P01EX
Definitely.

Interviewer
Ok brilliant. So anything else at all that you want to say or?

P01EX
No just thank you for letting me take part. I have really enjoyed it.

Interviewer
You're welcome

P01EX
I am glad I came, no that's it.

Interviewer
Brilliant well thank you very much for your time.

Interview 2

Interviewer/Transcriber - Robin Tahmosybayat

Participants: P02EX

Loctation: Northumbria University Biomechanics Lab in Sport Central.

Time: 20 minutes

Interviewer: Ok so participant number two, post interview for exergaming.

Q.1.What are your thoughts on the training program? Did you enjoy it?

Interviewer
So what are your thoughts on the training programme? Did you enjoy it?

P02EX
Yes thoroughly enjoyed it actually.

Q.2. Anything specific that stood out about the training program? (Favourite game? Favourite movement?)

Interviewer
Yea? Anything in particular about the programme that stood out for you?

P02EX
It was fun, you know? I'm competitive anyway

Interviewer
With yourself?

P02EX
With myself so… I would have made an effort to try to beat the score I did before, you know what I mean?

Interviewer
It's a good trait to have as well yea.

P02EX
So it was good fun that way and you didn't really think you were doing much in the way of exercising until you felt a little twinge or…

Interviewer
Yea… do you think that's maybe because your focus is elsewhere or on the actual game I suppose?

P02EX
Yea you're focusing on the game and when you've done that part of the game it's like "oh" its sorted me knee out or sorted me… you know.

Interviewer
So was there a favourite game that you had?

P02EX
Ay probably the picking up the pots and putting them on the shelf.

Interviewer
Ah yes the "Grab" game yea?

P02EX
Good fun that was. It certainly got you moving haha

Interviewer
It was quite a dynamic one that one wasn't it?

P02EX
Ay.

Interviewer
Yea and you had a good technique in that game as well which is why you actually getting the high points in that end. So was there any favourite movement that you had or was it again that same game?

P02EX
There was that but I liked a lot of them actually. The piano one I quite liked. The ones that stick out in your mind are the ones that you felt most comfortable with.

Interviewer
Right ok. Which were they? The ones that go to the side? or the ones that go to the front or?

P02EX
All of them ones probably. All of them ones. Probably the easiest one would have been the… fishing hook where you just…

Interviewer
Where? As in like the first game yea?

P02EX
Yea I mean that one yea.

Q.3. How do you feel after a particular session during the training program?

Interviewer
Ok yea. You just mentioned briefly before you didn't really notice during the session but after the session you said you could feel it. Did it make you feel like yes you have had a workout? Felt good?

P02EX
Yea I felt good like I had actually done something, worked up a sweat you know?

Q.4. Any aches or pains that have gone away? Have come back?

Interviewer
Yea. Did you have any aches or pains at the start of the programme that had gone away or are you feeling fitter or are you feeling no different?

P02EX
Oh I am definitely feeling a bit fitter I think in myself. Certainly enjoyed it and the osteoarthritis in my knees because of the exercise and that was warming them up and when I was out I wasn't limping or

Interviewer
Were you not feeling like there was much pain in your knees then?

P02EX
No because what happens is that once you warm the knees up it seems to ease them and you walk a lot easier afterwards.

Interviewer
Out and about?

P02EX
Yea.

Q.5. How does this compare to other types of training programs you have been a part of?

Interviewer
So obviously you have done this training programme. You have done a few other training programmes as well. Obviously they have been exercise based, but how does it compare when you have got that cognitive element to it. So you are playing the game…

P02EX
It's completely different. It was sitting down mainly and it was upper body. It wasn't strenuous but unless you put in as much as you wanted to I suppose. It was more stretching than anything else. We had a… lot of stretching

Interviewer
But I mean any others that you have done elsewhere in the past or?

P02EX
Yea I have done a speed flex one before, which was definitely… challenging haha. You tend to get in with it. It was… I don't know if you have ever been to speed flex but the beauty of speed flex is a special machine that works with hydraulics so you can't straighten your muscles. So you get a thoroughly good work out but you never.

Interviewer
Never lets you go beyond your limits?

P02EX
And what I liked about it as well, you had a heart rate monitor.

Interviewer
Right ok

P02EX

I've still got it in the house somewhere, I have to take it out haha. I keep meaning to where it when I was on my walks but uh, you sort it worked within zones. You know, competing all the time.

Interviewer
Ah cool. So that's like instant feedback in a way isn't it? Similar to this in a way as well.

P02EX
Yea because you were wearing it and it was logging you and I could work with a 25 year old on my left and we would both still be working in the red zone as it was adjusted to my age, body and all that so. It's probably a damn good idea for gyms actually because you have got a visual display straight away of how hard you are working. Plus it was in certain zones like colour zones.

Q.7. Would you do it again?

Interviewer
Yea yea so it's easy to kind of see where you are at, ok and so would you do this kind of training if it was available somewhere. Like, if all you had to do maybe is like ring up and book your appointment and then you would go out and do your daily activities then you would pop in for half an hour and you would do that. Like you had been coming here essentially but it's just as part of your week or… it's part of your daily routine to pop in, do your computer gaming…

P02EX
As long as it wasn't too expensive

Interviewer
Yes of course of course yea.

P02EX
I think the most off-putting thing for the older generation, my age, I'm a pensioner you know. I've got finite resources, you know, unfortunately I had lost my job years ago and ended up losing my house over it so now I have to rent so basically my pension is my rent.

Interviewer
Yes so this would have to be financially feasible

P02EX
Yes it would have to be financially feasible to be worth it, you know.

Interviewer
Yes I get that. Would you come and do this again?

P02EX
Definitely because it's fun.

Q.8. What would you change about training program (Exergaming, Staying Steady) console, game) to make it more engaging?

Interviewer
I understand there was some, obviously, there were some things that maybe you would change? Like obviously, we changed the games when they just weren't working, you know, but that's just teething problems with technology and software. It's inevitable really it's going to be there…

P02EX
Oh yea

Interviewer
But would it stop you using this concept altogether? Like using exergaming to train balance. Do you think it would stop you to do that altogether?

P02EX
Oh no.

Interviewer
You would still be motivated to come and do it?

P02EX
Yea I mean me and our lass have got a Wii at home.

Interviewer
A Wii? Yea with one of the little platforms?

P02EX
Yea I've got the balance board but we couldn't get it to work with the disc we have or it just wasn't synced so that was off putting. We could do the bowling and the golf and what have you and its good fun. Been competitive with me and my lass to be honest with you haha.

Interviewer
Its good crack though isn't it.

P02EX
Its good fun because you are both doing it and you are not sitting and watching tele all the time. You know, so it's something you can do together.

Interviewer
Ok yes that makes sense. So if there was something you would change about your visits or about the games or anything… to make it a bit more engaging for you? Is there anything that you would change?

P02EX
Hm not really. Maybe a bit of music with the game.

Interviewer
With the games yea.

P02EX
Because when I did the speed flex thing, that was always on and the music was the pace of when you did the workout.

Interviewer
Right ok so they attuned the music speed with the speed that you were essentially going at?

P02EX
Where you're working the same as the different group, even though you're all different ages you all have your heart rate monitor on so you could say well "I'm 86%" or "95% working" or things like that. Having a visual feedback immediately you know it's doing you good you know you're working hard with it and you're giving it your max you know.

Interviewer
And how do you think that would compare to going and doing these exercises in a group class?

P02EX
Group classes are good because you've got similar people doing the same thing and you're sort of interacting and you have a bit of a laugh with that whereas if you got to a straight forward gym you work in isolation.

Interviewer
So less motivating or?

P02EX
Which is a bit off putting because a) you don't really get any feedback unless you're sort of logging everything yourself, you know what I mean?

Interviewer
It takes extra effort doesn't it?

P02EX
Oh it does yea. It does. I mean I did it once where there was a group of us and we used to have coffee and biscuits afterwards with one of the lady's that ran the older group but if you got there a little bit later than normal, you did a little bit less, shall we say, on the thing to sit down and have a..

Interviewer
A coffee? Yea I see the social side of its quite important really isn't it?

P02EX
Yea it is.

Interviewer
Doing it alone is one thing but doing it with people, you've got something to share something to talk about haven't you?

P02EX
Yea. Share your aches and pains haha

Q.9. What are your perceptions on safety of using this method (Exergaming/ Staying Steady) to train balance? (Self-efficacy) Were you anxious at all during training? (Anxiety)

Interviewer
Haha essentially yea. That's it. We all get them. Did you feel safe when you were doing the exercises or? In general yea. There were no issues with any movements that were unsteady or?

P02EX
Well the only ones that caused me problems were the lunges

Interviewer

Yea the lunges yea. I mean did you feel it was safe doing them?

P02EX
It was because of my knees as they have a tendency every now and then to give out. So I am very weary of relying just on my knees themselves you know what I mean?

Interviewer
Yep. Yea I know what you mean.

P02EX
I tend to use… the handrail whenever I'm going up and down stairs it's the handrail, I always use the handrail.

Interviewer
That's understandable. If you don't know when they are going to give out.

P02EX
I'm just walking along and all of a sudden it just gives and you don't know what it is. It's momentarily but that odd time if you are off balance as well.

Interviewer
Have you ever tried… has that changed at all over the past few weeks? Have you experienced the knee giving at all?

P02EX
Yea I have on my walks. Not on my exercises but you don't really know when it's going to happen. It just happens.

Q.11. How do you feel the training program impacted your level of fatigue? How did this impact your motivation to train?

Interviewer
How does it feel on your walks? Ever since you started this training?

P02EX
Easier.

Interviewer
Does it?

P02EX
Yea. I think it's because I'm using my joints more. With walking it's just using the knees, ankles and the hips I suppose. Your arms swing a little bit but… being the walk leader you have to walk at their pace and not your own. Unlike Saturday where I just went for a walk on my own. It was more like a…

Interviewer
A hike? Haha

P02EX
But I ended up doing eight mile. I wasn't going to. The idea was a six mile. I just missed the cutting in the wood so went around the corner and I came back and went through the wood and down and I went through this… it's supposed to be a public footpath, I got half way along and I was soaking up to there (points to mid thigh).

Interviewer
No way!

P02EX
Because the weeds were up here (points to hip) and the ground was so uneven, actually it was if I was ploughed through haha

Interviewer
So when was this one then? Just the other day?

P02EX
Saturday just gone. So I ended up coming back because I thought I am not going to take a chance because I was heading down towards a stream anyway and I thought it's going to get worse down there so… I took another path and it took me longer than I wanted it to. Aching a bit at the end of that but it was very warm day, Saturday.

Q.13. Can you tell me how you feel when you go about everyday activities? Are there any fearful moments you have or concerns when you are out and about? (falling over)

Interviewer
Yes I imagine it was. So whilst you are out and about or whilst you're doing your daily activities, do you get any fear of falling over? Or has it changed since you have been doing this (exergaming) when you're out and about? Do you feel more confident or do you still feel fearful?

P02EX
I feel a bit more confident now. I still don't take chances like the stairs

Interviewer
Like you just said there when you took that different path there as well. Was that just because it was the wetness of the other one?

P02EX
It was because the ground was uneven and I thought that if I fall and hurt myself

Interviewer
And you were on your own as well…

P02EX
And I was on my own, a sprained ankle or something. I mean you are in the middle of nowhere.

Interviewer
Essentially, that's common sense as well. You're on your own going somewhere, you are going to take the safest path aren't you.

P02EX
Yea

Q.12. Did the training program feel negative in any way in terms of your self-thoughts? (Negative self-talk) Did you feel absent during the program? Could you sleep ok? Slowness of thoughts? Angry?

Interviewer
Which makes sense. So you have said you are feeling better now that you have done the six weeks in your other activities but is there anything that… have you had any negative self-talk at all during a session? Have you felt absent? Has anything effected your sleep or anything like that?

P02EX
No.

Interviewer
No. Ok brilliant.

P02EX
The only thing I have missed out of the six weeks are having those two days as my free days.

Interviewer
Right. I see yea.

P02EX
And I have missed my free days haha

Interviewer
Is it because of the lie in? haha

P02EX
No no not because of that, because I could have done a walk on a Wednesday morning you see. Not so much a Wednesday because I've got my granddaughter in the afternoon anyway. It's a Friday and I don't know what it is. I've missed them

Interview
Having just the free time?

P02EX
They are my free days where sometimes I feel I just can't be bothered to do anything, ah just the hell with it. I will do nothing today.

Interviewer
Just chill.

P02EX
Just chill. I have missed my, more my Fridays than anything else.

Interviewer
So it's the free time really

P02EX

Just the odd days that I have free. You know so I sort of missed them a bit. I won't do that again. I will pick days when I will do a walk in the morning and then do something in the afternoon. That will be fine you know. I like to have an option. A free day.

Interviewer
I like free days.

P02EX
Then look at the weather and I think you know like I did Saturday. And my partner said "well I am just doing housework today, get yourself out" haha "on a walk and I will get on with the house work" you know so off I went.

Interviewer
If there was somewhere for you to go, like I was saying before, like you said "get out I am doing the house work" would you feel alright if you booked an appointment to go somewhere to do this? It would give you something to do whilst you are out and about on your day as an option. Like you said you like the option of going somewhere, you like the option of going for a walk, you like the option of doing nothing. So if there was somewhere where you could ring up and it was cheap enough, like I said before, you would go for it?

P02EX
Well you see because it's like… I'd be like one of the walkers at Benton. They've got the option to say no. I'm not going to go for a walk today. But as the leader, I haven't.

Interviewer
Ah right ok I see. Some people don't want to go out in the rain.

P02EX
So like Wednesday it wasn't a full day on my own, but Friday it was and I have missed them option days you know.

Q.15. Is there anything else that this training has done for you that you would like to comment on?

Interviewer
Ah right yes. Is there anything else about this type of training that you would like anything about? Like the session?

P02EX
No I have thoroughly enjoyed them. If they flowed a bit better as well. Once you got used to the… it be nice to…

Interviewer
You mean without the tutorials?

P02EX
Yea. If you knew what… you were meant to do…

Interviewer
Yea. Yep so that's the thing because I was changing it all the time I felt like the need to leave them because some people were needing the tutorials but then if I had known that you had known the movements then I would just left the tutorials out and it goes over a lot quicker.

P02EX
Ay, I think it would flow a lot better. But I don't know if it had a little switch or something

Interviewer
Ah right like a remote just to click

P02EX
You could click it and so you skip that little bit.

Interviewer
That's a great idea

P02EX
Because it's sort of like stop start isn't it.

Interviewer
So I mean sometimes you did need a little bit of rest between the games.

P02EX
Yea I did find towards the end with that one that has you darting about… um… you did need that little break in between

Interviewer
Yea but not the other ones at the start as the session was designed so that you would kind of warm up into it, do the hardest stuff in the middle and you'd cool back down towards the end of it. Did you feel like that's how it was for yourself or?

P02EX

It did feel as if it eased off slightly and you noticed it was slowing down a bit at the end. But that's probably because I was a bit tired towards the end haha you know

Interviewer
Yes. Brilliant well thank you very much.

Interview 3

Interviewer/Transcriber - Robin Tahmosybayat

Participants: P06EX

Loctation: Northumbria University Biomechanics Lab in Sport Central.

Time: 15 minutes

Q.1.What are your thoughts on the training program? Did you enjoy it?

Interviewer
Ok so participant number six, exergaming group, post six week training interview. So what are your thoughts on the training programme? Did you enjoy it?

P06EX
I did and um I thought it was actually quite good for me because of having a weakness in my left leg… so it was very useful in that respect.

Interviewer
So you say you have a weakness in your left leg… has it improved or?

P06EX
I don't think the weakness has improved, but my overall balance seems to have improved.

Q.2. Anything specific that stood out about the training program? (Favourite game? Favourite movement?)

Interviewer
Ok fantastic. Um, so was there anything specific that stood out about the programme at all? A favourite movement a favourite game?

P06EX
Just the ones that were difficult were the ones that stood out. The ones I found difficult to do.

Interviewer
Can you name them?

P06EX
There was the one that was the knee bend because it was getting the actual knee bend right because I tended to bring the thigh forward so keeping the thigh down was difficult. The ones where it was standing on one leg and feeling it in either hip…

Interviewer
In the supporting leg? Right ok in the muscles?

P06EX
So um, well I was concerned it was the joints but I think it was the muscles. It came back to the fact that it was putting pressure on the muscles and therefore it was probably doing them good.

Interviewer
Yep, no pain no gain as they say haha

P06EX
That's it.

Q.3. How do you feel after a particular session during the training program?

Intervewer
So how did you feel after a particular training session with me. So afterwards, when you go away, do you feel better? Do you feel.

P06EX
Oh yep, lively, yep.

Interviewer
Like you have had a good workout?

P06EX
Yep. Because we didn't have a session on Friday, and we didn't have a session last Wednesday, I actually did a similar set of exercises.

Interviewer
Oh at home?

P06EX
Yea

Interviewer
Oh right really? So you felt motivated to do that at home because you had been here to do this?

P06EX
Yea. Yea. I want to keep it going yea.

Interviewer
Brilliant so this sort of thing has motivated you to do stuff on your own then? Additional stuff.

P06EX
Additional stuff yea.

Q.5. How does this compare to other types of training programs you have been a part of?

Interviewer
Ok. How does this compare to other training programmes that you have been a part of?

P06EX
Well… I've never really… because… I wanted to get back to running. After I was ill I had a lot of exercises to do and I had the incentive to do that because I wanted to get movement back in my left leg and get back to fitness. But really once I got back to running, I let those drift away. They had been useful but now I have come to the conclusion that because of this additional exercise is worthwhile as a support. Now, I'm running but that's the only thing I was doing so the additional exercise is a complimentary factor to the running.

Interviewer
Right ok. Yea ok. Brilliant. So you can say that this is helping your running essentially.

P06EX
Yes.

Q.7. Would you do it again?

Interviewer
Ok and would you like to do something like this again?

P06EX
Yep.

Interviewer
So you would come to the university or would you go to a research centre where you could book an appointment to do it?

P06EX
If it's a research thing I am more than happy to do it. I wouldn't go out of my way to use the software necessarily because I think it has given me an idea of what is useful to do by myself.

Interviewer
If it was available to buy? You could have it at home to do it at home?

P06EX
Well somebody was saying it's sort of like the Wii type thing you know?

Interviewer
Right yea similar to the Wii, in what sense?

P06EX
Well I've never used one but I was just describing to someone some of the exercises and the hard movements and that's similar to some things on the Wii.

Q.8. What would you change about training program (Exergaming, Staying Steady) console, game) to make it more engaging?

Interviewer
Right ok. What would you change about the training programme to make it more engaging?

P06EX
Haha well its (Mira) quite American, obviously, so you know that straight away.

Interviewer
So you would have a local person on the voice?

P06EX
Yea… fishes… haha

Interviewer
Right ok haha. Anything else at all or?

P06EX
Some of the exercises seemed… a bit simple.

Interviewer
Too simple?

P06EX
Well I don't know because I guess it's a balance because it's like a warm up, you know, and then a warm down. So I guess in that respect, its right and the ones in the middle are the toughies.

Interviewer
So if you were to pick the games that trained balance the best, or the movements or?

P06EX
I liked the squat one.

Interviewer
Is that the lunge one?

P06EX
The lunge one yes because… if it had been a little more complicated. I mean it was very straight forward.

Interviewer
Do you mean the onscreen element?

P06EX
Yea.

Interviewer
So maybe not just going side to side for the lunge one.

P06EX
But um, I found that really invigorating and I thought "Oh god am I doing this?" you know? Because I didn't think I could.

Q.10. Were you conscious of the movements being conducted during your training session? Where was your attention? Did you enjoy the experience? Worried about performance? Did you feel in control?

Interviewer
So were you conscious of the movements whilst you were doing it?

P06EX
To start with yes, but then it got to a point where I was doing it more automatically. I enjoyed the airplane one for the visual.

Interviewer
Is that the one where you had to shoot the targets?

P06EX
That's right yep.

Interviewer
So you are saying that at the start you felt conscious of the movements but then you gradually started to become more immersed in the game or?

P06EX

That's right.

Interviewer
Is that because you were enjoying it? Or was that because you wer conscious of your performance or?

P06EX
Yea because the longer it went on, the more number of weeks, you knew what you were doing, largely, I know you changed it a bit but so it was more performance related yes.

Interviewer
Would you consider yourself a competitive person? with yourself, like, internally?

P06EX
Um, with myself yes.

Interviewer
So you say you wouldn't really go to a centre to do it or you wouldn't buy it and do it at home?

P06EX
I don't think so

Interviewer
But it has inspired you to do the movements at home on your own, right?

P06EX
Yep.

Interviewer
Ok brilliant. Did you feel in control at a given session?

P06EX
Not always. You know when it doesn't quite go right. It's like "what did I do wrong there?" You feel like you are doing it right but you don't know what you are doing wrong.

Interviewer
Right ok, so was that because of the game, do you think?

P06EX
I think sometimes it was the setting wasn't quite right. You know you were going to the left and it wasn't going far enough across.

Interviewer
It would invert wouldn't it. You would step to the left and it would go to the right.

P06EX
Yea.

Q.11. How do you feel the training program impacted your level of fatigue? How did this impact your motivation to train?

Interviewer
Ok. So do you think your levels of fatigue have been impacted by this training?

P06EX
I think my recovery is actually better, well, I will give you an example, because I ran seven and a half miles on Friday and I thought I will rest it Saturday and Sunday. Monday did eight miles. We were out for over 3 hours because it was stop start and I thought yesterday I just wanted to get a run in and you see I am that competitive with myself, I ran far harder than I should have done and that I wanted to yesterday because I could.

Interviewer
That sounds as though you haven't really pushed yourself beyond your limits though still, have you?

P06EX
I think I did yesterday because I felt my recovery from the previous day had been better. So I have got to go out today and do two runs today so I will see how I get on.

Interviewer
Ok Brilliant. So still on the topic of fatigue, are you running more now? Since the start of the programme?

P06EX
A little bit more.

Interviewer
Do you think that is because of this or do you think its general time?

P06EX
Well, two things. I've just got a target of hundred miles per month and I've missed a few days this month and at that point I thought it doesn't really matter I don't have to do it but now because I've actually done a concentrate block of exercise I feel like I can get that hundred miles in.

Q.12. Did the training program feel negative in any way in terms of your self-thoughts? (Negative self-talk) Did you feel absent during the program? Could you sleep ok? Slowness of thoughts? Angry?

Interviewer
Ok brilliant. So did the training programme feel negative in any way in terms of your self-thoughts? Like any negative self-talk or did you feel absent during the programme? Was there any interruption in your sleep patterns or…?

P06EX
Nope. Slept pretty well. The negative side for me was like knowing that I still have a problem with that leg and that it's the weaker leg because I tended to forget about it so that brought it back to me, you know, but in a positive way I guess.

Interviewer
It was making you focus on improving it maybe or..?

P06EX
Yea. Yep.

Interviewer
So you would feel the weakness in the leg and it would remind you that you still have something to work on?

P06EX
Yea.

Q.13. Can you tell me how you feel when you go about everyday activities? Are there any fearful moments you have or concerns when you are out and about? (falling over)

Interviewer
Ok. So whilst you have been out, obviously you run and you are trying to get 100 miles per month. So your everyday activities must be… it's not a difficult thing for you to get out of bed, its not a difficult thing for you to go downstairs as such like that. Do you have any fearful moments or concerns while you are out and about, whether it's running, walking, going upstairs?

P06EX
I still have a balance issue to a certain extent. On Monday I was on very uneven ground at times. Particularly, if I am going forward on a slope and I really had a lot of difficulty there. I was up at the Roman wall on Friday and it started to rain and on the stoney sections had to be really careful. That's two fold though. That's with age as well. When you're younger you just go for it and don't think about it. As you get older you've got more feeling of the consequences of things going wrong, you know.

Interviewer
No I do understand that one hundred percent. But you haven't had any adverse events or you haven't fallen at all during the last six weeks?

P06EX
No. No falls. I've had a couple close calls tripping but just propelled myself.

Interviewer
Ok and do you think that's a natural occurrence?

P06EX
Yep.

Q.14. How confident are you that you will not lose your balance or become unsteady in everyday outdoor and indoor activities now that you have received some balance training? E.g. Up and down stairs? Standing on a high surface? Escalator in shopping mall? Quick turning?

Interviewer
Ok. So how confident are you that you will not lose your balance now or become unsteady? So you mentioned the slipperiness of some of the rocks and would it make you think ok I can do this now or..?

P06EX
Um, we'll take it the other way. When it's a difficult surface I will still have to be careful

Interviewer
But it wouldn't stop you climbing it or..?

P06EX
No. No, but also I used to be a fell runner. So we used to make up a lot by coming down fast and just leaping and I have got a feeling to do that again. You know when its decent conditions I have got less fear to do that than I had before, yep.

Interviewer
At the start of this programme? Really? That's fantastic.

P06EX
Yep.

Interviewer
So there is an element where it is slightly reduced and you are not as fearful or you are considering doing something that previously you would have been more apprehensive.

P06EX
The other thing I have noticed is, particularly on the treadmill, is I am getting back into a more open running style, a longer stride that I had lost because the short "pitter patter" type of stride pattern. I am getting back to a more, well faster for one thing but a longer stride pattern. A more open stride pattern which.

Interviewer
What do you think that's down to then? Which element of the training programme?

P06EX
I don't know… well it's partly the balance. The confidence. Balance confidence and a little bit of more endurance in there. You know perhaps some muscle strengthening.

Interviewer
Yea so this obviously required you to do lunges and yes there were some simpler movements but there were the more rigorous ones like the hip abduction where you had to go to the side and these are all muscles that essentially will affect your running patterns, you know? So there was some strengthening element to the training as well.

P06EX
I think so yea.

Interviewer
I mean it's all multi component really isn't it? Do you think you would have managed ok doing the whole six weeks without any chairs for support?

P06EX
Um no. I think I could develop.

Interviewer
So if we had carried on more than six weeks do you think maybe you would have eventually been ok without the chairs to do the exercises?

P06EX
Um, I'll qualify that. I think I would have used the support less if it had been higher. So it would have been a cursory. It wouldn't have been a physical lean, it would have been a cursory.

Interviewer
As in like it wouldn't have changed anything in your posture as well?

P06EX
It would have been better for my posture because the stool, the height it was, I was tending to bend over whereas if it had been something there (higher up) I think it would have made a big difference.

Q.15. Is there anything else that this training has done for you that you would like to comment on?

Interviewer
Is there anything else you would like to say about the training sessions or the programme? How about the cognitive side to it?

P06EX
Well I do some stuff anyway, you know along the lines. The text and the colour. So I do some work like that anyway just on a daily basis. So I was familiar with some of the concepts but actually I have improved from doing it on my computer from doing it here.

Interviewer

Do you think that could have anything to do with the fact that you weren't just sat down doing it on a computer? You were trying to do movements as well? So you had to broaden your concentration.

P06EX
That's right yea… because if it's just a mouse or a keypad, it's a lot different to actually physically doing it.

Interviewer
Physically moving to do it yea. On the exergaming sorry yea.

P06EX
Yea. So it gives you more conscious appreciation.

Interviewer
There's not really a lot more but if there is anything else you want to chat about feel free to talk about it. Yea so your favourite game was the lunges then was it? I thought you would like the reach one (GRAB).

P06EX
Well I was going to say that one as well. That was the one I felt most competitive at because I seemed to be developing techniques and different styles of doing it you know like the sweeping one.

Interviewer
Yes I had noticed over the 6 weeks you had adapted different strategies. From picking up the vases quicker to getting them on the shelf quicker. Ok brilliant well that's everything thanks.

Interview 4 – P07EX

Interviewer/Transcriber - Robin Tahmosybayat

Participants: P07EX

Loctation: Northumbria University Biomechanics Lab in Sport Central.

Time: 30 minutes

Interviewer: Hello.

P07EX: Hello.

Q.1.What are your thoughts on the training program? Did you enjoy it?

Interviewer

Ok so first of all, what were your thoughts on the training programme?

P07EX

On the training programme? It was challenging and a) I'm not an advocate of computer games. The only computer game I play is solitaire, that's all. The challenge was when I didn't do so well and you feel rotten. You get annoyed at it. You get annoyed at yourself sometimes because I knew what I wanted to do but I would go the wrong way. I think that is part of my coordination or the brain, that working.

Interviewer

Yes because it's almost… it's because you are doing two things at the same time and its demanding more… capacity, coordination…

P07EX

Yep. Coordination… the whole lot, yes coordination.

Interviewer

Yes. So did you find it challenging?

P07EX

Physically challenging. Some of it was physically challenging. Well I had some problems physically, but most of them like the leg movements… I couldn't say that I found those physically challenging. It was more mentally challenging in that I wasn't doing what I really wanted to do.

Q.2. Anything specific that stood out about the training program? (Favourite game? Favourite movement?)

Interviewer

Was there anything specific about the training programme that really stood out? So favourite game? Any particular muscular pain?

P07EX

My favourite games were the ones I was good at.

Interviewer

Ah I see.

P07EX

I liked the stand up one because I could manage that one. I liked the colour blocks. The one I had the biggest problem was those squares with the designs on the front. It wasn't the physical activity, it was my memory. As I say I found the symbols difficult to relate to. I think I would have found, if let's say it had been an apple and a pear or something that I would remember or remember it was, what was it? Toaster, tennis ball and shoes. I would find that easier.

Interviewer

Yes because they are everyday objects.

P07EX

Yes and you could relate to them. The brain can relate, whereas I couldn't form a relationship with any of those little squares in that one.

Interviewer

I see. So if it had been things that you were pretty much used to looking at, you think your memory performance would have been better?

P07EX

Yea I think my memory would have been better.

Q.3. How do you feel after a particular session during the training program?

Interviewer

Ok that's some good insight there. At the end of a particular session, so it can be the first session, it can be the last session we did, how did it make you feel? We're not talking about anything external to the training so just coming and taking to me and having a go at the games.

P07EX

I quite enjoyed the experience, especially the Friday one. The Wednesday one where I was going to the shop afterwards was always "get done got to get going", whereas the Friday one I didn't have to do anything else so that was easier for me the Friday ones.

Interviewer

Right so when it's not in the middle of doing many things.

P07EX

Yes and also I have had a very bad few weeks.

Interviewer

Yes I know as you have said.

P07EX

I mean there was the dog and that was the excitement of the show… I mean because the show happened because… yea the show happened while I was involved and then I got the dog, I waited for the dog and I was visiting the dog at the cat and dog shelter and then I got him and I just think that all this business of Terry and this guy with the patio and everything so um its hasn't been…

Interviewer

Well I know these things have been happening outside of here but you have still shown…it hasn't shown in your physical capabilities any difference.

P07EX

Yes and I have come. I could easily have backed off. It's the same with my aerobics at Concordia. I have gone. I know it's important to go you know.

Interviewer

Yes sometimes you might not feel like it but…

P07EX

The day I was informed about Terry's death I didn't go but the next one that was available, I resumed and carried on.

Interviewer

Ok. So like you have said you have been a part of an aerobics class for how long?

P07EX

For over three years.

Interviewer

Over three years so that has been quite a constant in your life?

P07EX

Yep.

Interviewer

So how would you say this (exergaming) would compare to this aerobics class?

P07EX

Well you see this is alone. The aerobics class is people and music and an instructor that I relate to and enjoy.

Interviewer

Yep so there you have group and social connectedness, here it's just me and you.

P07EX

And I mean if I were doing it at home it would be just me and the television.

Q.5. How does this compare to other types of training programs you have been a part of?

Interviewer

That was going to be my next question. So if you had a choice between the two… if you had this (exergaming) at home would you still do it or would it be something that you would rather go out and do?

P07EX

I think I'd rather go out. I mean like when they said at staying steady "Do the home stuff", did any of us do the home stuff? … Very few people.

Interviewer

Very few people do it at home.

P07EX

It doesn't… you need the discipline and also five classes. I've got to pay. I pay buy direct debit and therefore it's costing me money and therefore if I don't go… if I'm paying for something I will go but if it's free then you think oh I needn't go but when you're paying for something then there is an incentive to go and to not waste money.

Interviewer

That’s good that makes sense. Going back to the aerobics class and you have done staying steady in the past as well. How did you find the movements here compared to those in the other programmes?

P07EX

They are quite similar to my aerobics where she does the strength portion except she doesn’t give us support. Well no we do use support on the wall when we are doing… that one (leg abduction). I’d say they are similar to the aerobics. Of course the aerobics we are moving more.

Interviewer

In between each… yep ok I see. Would you say that this has more cognitive challenges though than aerobics?

P07EX

Yes definitely.

Interviewer

And so combining the two, we call it dual tasking. So in an aerobics class you have an instructor that you are looking at and are following the exercises that you can do. Here you do have a tutorial before the game starts but then you have to focus on the screen whilst doing the movement so it’s almost like it’s getting you to do two things at once.

P07EX

Yep.

Interviewer

Is there anything in the aerobics or staying steady where you felt you were doing something like that?

P07EX

The aerobics are always the same so you could do it on rote. I mean I could do it with someone at the front saying “right Jacks, half jacks, knees up, step forward” you know that. I could do it that way without her. It’s sort of a rote. I mean you follow other people even if you can’t see the instructor. You follow other people. You follow the crowd. Here… I’m focusing on playing the game. There’s no one… and that’s how often it will tell you I am not doing the thing right or something like that. It would be easier, I think with this situation, to do the exercise incorrectly because there’s no one sort of monitoring you.

Interviewer

You mean in the aerobics class?

P07EX

No, here. If I was doing that. It would be easy to not do it correctly.

Interviewer

Ah ok but there is the element of this gaming that if after a period of time you're not doing the movement correctly, they pause the game and they show you the correct movement again. I was here during all of the training sessions so if I saw it I was kind of telling you as well.

P07EX

Yep. Like telling me to bring my feet together you know.

Interviewer

Yes like that yes.

P07EX

But I mean again at home… there is a lot of technology to go in. If you are talking about an individual buying the system, the end product. Then there is a lot of technology that has to go in and I would imagine pretty expensive technology for it to be available for a person to just go and…

Interviewer

Buy off the shelf for example? Yea. I mean it doesn't compare (financially) with specialist equipment but yes it would still be a certain price for an individual to go and buy themselves.

P07EX

It might be better in an institution where maybe they can come to a session and hire in or something, yep.

Interviewer

So maybe a centre where you could come and have lunch, have a coffee and then you could say ok I am going to do my session now and some people can come and watch you and help as well.

P07EX

Yes or book it or something like that. I think it might be too expensive to do at home so if I came to a centre like this then I'd do it, whereas at home, I can't. Say the phone goes or something happens, the doorbell rings, you know?

Interviewer

Yes.

P07EX

Whereas in a centre you've got the …

Interviewer

An appointment.

P07EX

Yea. Yea it's… you know it's structured. In a home setting, things could come up. Somebody comes to the door or the phone rings.

Interviewer

So you would have to pause it.

P07EX

The benefit I think would go and you need to keep doing them for the 30 minutes o however long it is. Not just 10 minutes here, Oh I'll have a cup of tea.

Q.7. Would you do it again?

Interviewer

Ok brilliant. Would you do it again?

P07EX

Yea I think so. I mean it's been six weeks… coming into town has been a bit of a chore. Especially when I was doing the other thing going on from here. A bit of a chore but I managed it and that's the thing.

Interviewer

If it was in a research centre nearer to your location?

P07EX

Well I mean Concordia, they have got a great centre there which you could put it in and it might work. You know? For some people it might work.

Q.8. What would you change about training program (Exergaming, Staying Steady) console, game) to make it more engaging?

Interviewer

Right ok so what would you change about the training programme? Like the console? The game? The instruction? To make it a bit more engaging.

P07EX

That first one with those objects.

Interviewer

Yep so more relatable objects.

P07EX

Yes more relatable objects, um, I get a little bit peeved with the instructor. She sounds very prissy.

Interviewer

Ok so the online instructor. If you were to have this (Mira) over a longer period of time and you got used to what you had to do, you wouldn't have to watch it.

P07EX

You could escape that and it would speed things up.

Interviewer

It would speed things up a lot more. Yep so online instructor's voice was slightly annoying, which is fair enough. I understand. I have been listening to it for a while as well.

P07EX

Where does it come out of?

Interviewer

The company? They were working in Manchester but they are from the United States. I can't remember the precise location but I know it's America.

Q.9. What are your perceptions on safety of using this method (Exergaming/ Staying Steady) to train balance? (Self-efficacy) Were you anxious at all during training? (Anxiety)

Interviewer

What would your perception of safety be with using this method (exergaming) to train… yes so first of all did you feel it was safe to do here?

P07EX

Yes with the chairs and the supports. Again for an older person, it depends of their capabilities. I don't think you could do it on a carpeted surface. It would have to be a liner or a tile…no not a tile. It would be difficult to…or end up on the floor on tile so whatever surface, remember these people have balance problems. A fall be quite detri… I mean you've got to protect against falls. So therefore you've got to have chairs or supports nearby.

Interviewer

Like a nearby support and obviously a carpet has more grip so doing the movements you would have to be careful and you wouldn't be able to do…

P07EX

You couldn't get the foot movements. It's got to be done…

Q.10. Were you conscious of the movements being conducted during your training session? Where was your attention? Did you enjoy the experience? Worried about performance? Did you feel in control?

Interviewer

Ok. When you were performing in the actual games, I was obviously sat watching, and you were paying attention to what was on screen but were you conscious of the movements you were doing whilst you were paying attention to the screen?

P07EX

I don’t think so. I was more… I wanted to win.

Interviewer

Yes ok. Brilliant. I think everyone wants to win when their competitive streak gets going don’t they?

P07EX

Yes. Unless there was pain. If there was pain…

Interviewer

Then you would have been aware?

P07EX

Yes.

Q.4. Any aches or pains that have gone away? Have come back?

Interviewer

In fact you pointed out a few times when you’ve had pain.

P07EX

Yep that I have had pain.

Interviewer

So when we did change the sit to stand exercise, I noticed there was a lot more repetitions in the Piano game and so you did start to notice that it was starting to effect it a little bit after say a minute or two.

P07EX

Yes. Yep and that’s something that’s there um.

Interviewer

That’s a constant now. Ok so you wanted to win. At any point did this make you feel worried about performance?

P07EX

Oh I wasn’t worried I realise it’s a game.

Interviewer

Yep because you know it’s a game so you know it’s not something that can make you feel bad.

P07EX

It’s not life threatening.

Q.11. How do you feel the training program impacted your level of fatigue? How did this impact your motivation to train?

Interviewer

Ok. Over the last six weeks do you feel you have been more tired because of this?

P07EX

Yes but again I don’t know if it’s because of it or the whole shebang.

Interviewer

Yes so it could be that external factors are playing a part.

P07EX

Yes definitely. I can’t say that this has tired me. The first time definitely I felt it.

Interviewer

I do remember you saying at the end of some of the sessions…

P07EX

Yea and I was a bit concerned as to whether this was going to be that way the whole way through, but it settled down.

Interviewer

After the first session you felt like you had a workout, but did you still feel like you could go about your day?

P07EX

Well I did straight away. It was just… it felt a lot of pain. I mean maybe it wasn’t this that did it. Because I had just done this for the first time then that’s why I associated it with that. I think it started on the Wednesday didn’t it? And on the Friday it wasn’t as bad. The Wednesday one would be a day when I have go to get to the shop. So there’s all that going on.

Interviewer

So I just mentioned that yes feeling tired but you said you weren’t sure it’s because of this and

P07EX

Other factors. No I don’t think it was because of this. I think it was the other factors.

Interviewer

Yes other external things.

P07EX

No I don't think it was because of this. I think it was the other factors.

Q.12. Did the training program feel negative in any way in terms of your self-thoughts? (Negative self-talk) Did you feel absent during the program? Could you sleep ok? Slowness of thoughts? Angry?

Interviewer

Ok. So I will ask the same thing in that did you feel negative in doing this (exergaming)? Or if you had any self-thoughts during the time period that you were in here about game experience or about yourself?

P07EX

I had other thoughts. There were times when… again with what's going on my concentration was not… my focus was not… there were other things going on. I am just annoyed that I didn't do better.

Interviewer

But you did do well.

P07EX

I know but it keeps telling me that I went down and maybe it shouldn't tell you. I don't know.

Interviewer

Maybe because it was giving you feedback

P07EX

Maybe it should only tell you when you do well haha

Interviewer

Yea so this the thing that's interesting because feedback is feedback. So positive feedback is always welcomed and negative feedback is …

P07EX

I mean it does make you want to do well but you don't feel well. Anyway it's only a game.

Interviewer

Yes ok. So now that you have done some of this training which is six week which is not a long period of time. Would you say that you are more confident when you're going about your everyday activities? I mean now you are walking more.

P07EX

Not really because as I say last Thursday night when I walked in the dark I was really worried but I managed it but that's not to do with this. It's happened before in the dark that I know I am unsteady and more unsteady in the dark.

Interviewer

Mainly because of the dark?

P07EX

Whatever it is. I could look as though I am drunk at times.

Interviewer

Right because of the reliance of vision.

P07EX

Yep.

Q.13. Can you tell me how you feel when you go about everyday activities? Are there any fearful moments you have or concerns when you are out and about? (falling over)

Interviewer

During the daytime when there is light would you say you felt any fear of falling over?

P07EX

No not really. I mean uneven pavement but all the folks… the council and I must have been just … and I went that way. I didn't fall but that's maybe what caused one of the falls I had last year because I had a fall that way but again I was rushing, got to get the bus da de da

Interviewer

Ok. So you'd say the fear of falling over was with you from before that fall and maybe this hasn't really impacted to say now you're not scared of walking but I did notice that you have a dog now so you have to go out and walk more?

P07EX

Yes.

Interviewer

Which is a good thing in a way as it gets you walking four more time a day you told me?

P07EX

Yes four little walks.

Interviewer

Four little walks, ok. So when you're holding the dog you…

P07EX

I let him off. I trust him. I walk him but on the lead at night. In the dark I walk him on the lead. In the day I think I find I seem to be better if I walk faster than if I walk slower.

Interviewer

So sort of more dynamic

P07EX

If you go slow you will balance but if I think…

Interviewer

It keeps you in momentum more.

P07EX

Yes.

Q.14. How confident are you that you will not lose your balance or become unsteady in everyday outdoor and indoor activities now that you have received some balance training? E.g. Up and down stairs? Standing on a high surface? Escalator in shopping mall? Quick turning?

Interviewer

I see what you mean. Ok so how confident are you now that you will not lose your balance or become unsteady?

P07EX

I'm not.

Interviewer

You not very confident?

P07EX

I don't know. I mean I am about the same. I mean there's always a fear because of.. I mean I know my balance is not good and I can see wmyself around the house. You know I can just… it's usually just me that will cause me to go that way and there's nothing I can do. I mean I think it's this (right knee arthritis) that causes the problem.

Interviewer

Ok because of the pain or ?

P07EX

The pain or because its weaker because when I do sort of lose… I go that way (to the right) so it must be that this side doesn't give me the support that I get from the left one.

Interviewer

I see. You still are a very active person considering. So you mentioned going up and down stairs…

P07EX

I will avoid them if I can. At home. I've got a stair lift at home but that's because I was carrying the dog upstairs. I was carrying the dog with one hand and one hand on the… and they said it was an accident waiting to happen, which it was because my other dog couldn't walk up the stairs. So the dog quite enjoyed the stair lift. I don't use it. It's sitting there but its there if I need it.

Interviewer

Like maybe if you have excessive pain in your knee?

P07EX

Yea but I do my stairs at home. If I'm in a public building I will avoid them because I go down straight legged … it's easier. Very careful and slow and if I am going up I raise my leg it doesn't put as much pressure on them.

Interviewer

On the knees.

P07EX

Yep

Q.15. Is there anything else that this training has done for you that you would like to comment on?

Interviewer

Ok. Is there anything else that this training has done for you that you would like to comment on? Apart from introducing you to me haha

P07EX

Yes it was charming. It was funny about you because the name Robin, I was expecting a small girl.

Interviewer

Yes. That's what people say haha

P07EX

To think you were a small girl haha. It's been challenging and it's good to have the mental challenge with it. But as for the physical exercise, that bending one. I found I have been aware of my limitation because I didn't think… we do that in the classes, in aerobics and I don't feel any problems but I was definitely was having a problem in doing that.

Interviewer

Do you mean going down and putting them up on the shelves?

P07EX

No this one. Well that one too going down but that one I thought that I… in my aerobics class we do it and I felt I was fairly well but here felt a restriction or a stiffness or maybe it's the... we were doing it to music. The ones bending down I was afraid of falling there because very often I can topple

Interviewer

Yes I can remember you telling me. Yea you can go forward.

P07EX

I can topple… in the house. Yea I can topple bending down for something.

Interviewer

Do you think this might have helped as it was forcing you to do it as part of the game? So sometimes you might avoid to do something like that because you are scared of doing it and because the game was wanting you to do it you were coming up with a strategy.

P07EX

I mean I've got to pick up after the dog… black bags. I think there is a thing that you can… Yea but I am having to do a lot of that at the moment, which is the movement that I was doing then.

Interviewer

But also it wasn't just bending down because normally you would be looking at the object you were about to pick up but this time you were having to look up at the screen.

P07EX

Yes if I had been taller I think it would have been easier because I found it also a lot of… the one with the stars… with the um shellfish?

Interviewer

Oh um fishes?

P07EX

Little stars, little stars.

Interviewer

Right ok.

P07EX

They seemed to be up the top. Always at the top of the screen whereas I felt it would have been easier if they came down a bit but all the action seemed to be at the top.

Interviewer

So what I did do at the start of the training programme was that a lot of it was more focused at the bottom and towards the end we wanted a bit more movement so we were putting objects, like the "busy the bee" game, where the flower were on the bottom and then we put them at the top to kind of get you to do more walking. But yes as long as it wasn't too strenuous or?

P07EX

I can't say any of it was too strenuous.

Interviewer

So overall you have enjoyed it?

P07EX

It's been fun, challenging but again as I say… in the home a) I don't know that I'd do it and I think that it would be pretty expensive to go in a home.

Interviewer

So you wouldn't do it at home if you had one? Even if it was at a cost… an ok price for you to have one, you would choose to… would you prefer to go out and about or?

P07EX

I'd prefer to go to a session or shall we say Concordia leisure centre where you could maybe… a couple of pounds or something and use it. I think that would be much more economic for people. But again, the exercises are not much good unless you are going to do them regularly, you know, this is all very well doing that but its

Interviewer

But it has to be week in week out.

P07EX

I mean I exercise regularly. I don't know how many of your other folks exercise regularly. I mean you have got them exercising but now what happens? You will regress unless it's kept up. This is it. It's got to be kept up, any exercise.

Interviewer

If there was a centre where you could go to and where you can book your appointment week in week out.

P07EX

Yep just book one of the machines.

Interviewer

Yep and then you would book it and then you would go and you'd do it and then you would go off. You could even go with people or there would be a group of people there doing it.

P07EX

Yea then you could maybe do it three times a week or something like that.

Interviewer

Yes and you wouldn't have to buy it yourself.

P07EX

No no I think it's going to be too… and then I mean if something goes wrong and something like that but if it's someone else's responsibility to keep it up there and um, someone did the session and um… fine.

Interviewer

Ok and just one last question. Do you think you have more balance because of it (exergaming?) As in the exercises were balance focused but do you feel it has improved your balance?

P07EX

I don't know. I'm not sure. I mean… to me the main balance one that I have had so much is standing on one leg. I think that's the main test. On tip toes and standing and holding that. To me they are the better bal… and I would have thought that kind of thing would have been on the programme but it didn't have any one legged. Well some of them were one legged but they didn't have the stand and they didn't have the tiptoe.

Interviewer

On this one we didn't have the tiptoe no.

P07EX

Staying steady do it on tiptoe and also on your heels.

Interviewer

Yes they do. That's one thing I have noticed. And they didn't do that in this one no.

P07EX

And they have you walking

Interviewer

In tandem stance.

P07EX

Which is very difficult. Very very difficult.

Interviewer

Yes because it's narrowing your base of support.

P07EX

Yea. Yep very difficult at holding your balance. When I used to work in the law courts and we used get all the drunk driving and the tests of he could not walk heel to toe. That was one of the tests of being drunk.

Interviewer

It is a difficult one to do I have to agree there haha.

P07EX

It is difficult sober haha never mind drunk.

Interviewer

Let alone drunk haha I can imagine that would be a lot more difficult. Ok well um that's everything. Thank you very much.

P07EX

Pleasure.

Interview 5

Interviewer/Transcriber - Robin Tahmosybayat

Participants: P08EX

Loctation: Northumbria University Biomechanics Lab in Sport Central.

Time: 30 minutes

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Q.1.What are your thoughts on the training program? Did you enjoy it?

Interviewer

Participant number eight. Exergaming group. Ok so what were your thoughts on the training programme? Did you enjoy it?

P08EX

I did. I thoroughly enjoyed it. I've missed it in the last week now it's finished. It has sort of motivated me into getting back into exercise, a little.

Interviewer

Ok brilliant. What do you think it was about it that motivated you to get back into exercise?

P08EX

Possibly being in the environment of a sports… hall as well.

Interviewer

Right ok.

P08EX

I also think that it has given me a little bit more confidence. Maybe because of your assistance Robin the way you encouraged.

Interviewer

During the training, during the programme?

P08EX

Yea. Yea.

Interviewer

Like having someone there to talk to or just to give guidance on… just in general.

P08EX

Yes. Yes.

Q.2. Anything specific that stood out about the training program? (Favourite game? Favourite movement?)

Interviewer

Brilliant. Was there anything specific that stood out about the training programme? This can be good, this can be bad so good and bad.

P08EX

The only time I felt something was bad was when I couldn't do it properly.

Interviewer

Yes and I think that was just down to technological issues with the camera or something to do with the game. It wasn't actually you. You were doing the same movement as everyone else, it was just the way the camera was picking up so.

P08EX

I was getting frustrated at myself. It wasn't really to do… I was just getting frustrated with myself.

Interviewer

Yea well I mean. I can't show the other videos where the participants were doing the exact same movements as you but I do know that you weren't doing the movement wrong. That's why when I said it's not you in the session, it's the technology, that's literally why. It's because for some people, in other movements, it wasn't doing it. So that is one of the hiccups of the technology at the minute. Because it's just a new technology at the minute, its teething. So these are little teething issues essentially but I hope it didn't ruin the whole experience.

Q.3. How do you feel after a particular session during the training program?

Interviewer

So how would you feel after a particular session? It can be the first session or it can be both. It can be one of the sessions at the beginning or one at the end?

P08EX

I think after every one I felt the way I use to feel when I used to go to a gym years ago. I might not have wanted to go but once I got there and I did it I felt great.

Interviewer

In terms of the feelings after, obviously you felt that your muscles had been worked. Did you feel like you had trained balance?

P08EX

Um hm, yep.

Interviewer

Yes?

P08EX

I do feel muscles for example the stretching ones and I could feel it on my body. So there were sometimes it was sort of around the hips area.

Interviewer

In any particular game that worked the hips?

P08EX

I think it must have been lifting the legs possibly sideways and then the stretching one with the items on the shelves. I'm sure that did me the world of good.

Q.2. Anything specific that stood out about the training program? (Favourite game? Favourite movement?)

Interviewer

Definitely. I would have liked to eventually have a game that is that dynamic, but with different types of games that use the same types of movements. That one you had squatting down, reaching, stepping and bending down. There was a lot of movements into one game there which I thought was… yea it was one of my favourites too. Did you have a favourite game?

P08EX

I probably liked that one. The items on the shelves and I liked the ones with the colours. You know when you had to choose… which weren't very… for your… for the brain.

Interviewer

Ah yes ok. So there was colour clouds where there were two different clouds and colour blocks.

P08EX

Where you chose… but I think it's because I like that sort of thing. Once I get the brain going haha.

Interviewer

You like something trying to catch you out you mean? Like a challenge?

P08EX

Yea.

Interviewer

Sounds like there's some competitiveness coming out here haha

P08EX

haha

Q.4. Any aches or pains that have gone away? Have come back?

Interviewer

So did you have any aches or pains at the start of the programme that have gone away since?

P08EX

I think I did. Probably just from the exercise after not having done any sort for a while.

Interviewer

How long has it been since you have done some exercise?

P08EX

I used to do yoga fairly regularly until about three years ago and then you sort of drift off and when you drift off, you don't get back into it.

Interviewer

Yea ok yea.

P08EX

But years and years ago I did all sorts of aerobic types.

Interviewer

Yea ok. Like going to classes and stuff like that.

P08EX

Yea. Yep.

Interviewer

I have never been to an aerobics class.

P08EX

Do you want to try it? Haha

Interviewer

I might do. It might be too dynamic. Think I will stick to my gym.

Q.5. How does this compare to other types of training programs you have been a part of?

Interviewer

Have you done any other types of balance training before? I mean I know you have been to yoga classes.

P08EX:

Yoga.

Interviewer

That incorporates quite a bit of balance doesn't it?

P08EX

Yea. Yep.

Interviewer

How would you say that this programme that you have just done, that six weeks of exergaming compares to something like yoga?

P08EX

I think it was probably better because you sort of worked into it more gradual, whereas when I have been to a yoga class, the teacher has to take into account new starters but otherwise it's straight into a balance pose.

Interviewer

Right yea and do you think that's to do with a comparison between yoga and exergaming or do you think that's because new comers, like you say, in a class. Maybe they didn't account for new comers coming into the class.

P08EX

Yea. Then you feel a little bit like…

Interviewer

Oh I need to catch up

P08EX

Yes.

Q.7. Would you do it again?

Interviewer

Ok that's interesting. Would you come and do the training again?

P08EX

Yes

Interviewer

Yes? If it was another bout of six weeks or just ongoing thing? So if there was a place that you could book your weekly appointment, like you book an exercise class and there was everything set up and you go in the room, with either your partner of friend if you want, then you just press play and start your programme. It tells you everything first and then once you had done it you can just go away, I mean it would be supervised.

P08EX

I think that would be great, but it would be supervised would it?

Interviewer

So it would be supervised by a camera and potentially, this is all theoretical, there would obviously have to have someone on site for safety and first aid. This would be something to give to the community. An additional option to exercise classes. Some people prefer exercise classes over training alone and some people prefer training alone or just with someone else.

P08EX

I think if it was sort of rolled out into... um... I was going to say women's institute but not necessarily that but somewhere like that where people of the same age, who might never have done anything?

Interviewer

Would be a good as an introduction to it.

P08EX

Yea or these sort of community centre places

Interviewer

I have been going to Gateshead where they have village halls where they have these sorts of things so maybe by having it set up there or something.

P08EX

Yea and it might encourage people who might otherwise not have done it.

Interviewer

Yea to come and have a go?

P08EX

Yea. I think it's something that should be used in the future. I mean I don't know the best place but with all the thought that has gone into it.

Q.8. What would you change about training program (Exergaming, Staying Steady) console, game) to make it more engaging?

Interviewer

Well hopefully we will have somewhere to set up or be approaching organisations in the future, I don't know yet. So is there anything you would change about the training programme to make it more engaging, like for yourself?

P08EX

I don't honestly… I don't think so. There may have been some of the exercises that I didn't really like because I couldn't achieve what I wanted to but I still think you've got to try. Even I might have grumbled but you know… haha.

Interviewer

Oh the lunging game, I see.

P08EX

haha

Q.9. What are your perceptions on safety of using this method (Exergaming/ Staying Steady) to train balance? (Self-efficacy) Were you anxious at all during training? (Anxiety)

Interviewer

Did you feel safe when you were using this method to train balance?

P08EX

Apart from when I had a fall.

Interviewer

Well yes, you had a fall but that wasn't during a session was it.

P08EX

No. No but when I had a fall in our balance…

Interviewer

Oh you mean during the assessments. So not in the actual training sessions.

P08EX

Oh no I felt safe.

Interviewer

Right ok. So that's what I mean it can be from literally when you've left your house to come to do the session. I mean at any point… but when you got to the university, you've come to the room and its set up and you just start. There's nothing like equipment wise or anything mainly that's made you feel unsafe or doing any of the movements that made you feel unsafe?

P08EX

Oh no. No. No.

Interviewer

No? Ok brilliant. What about anxiety? Was there any anxiety during the training?

P08EX

No I don't think… no. Probably just thinking about lunges when I realised it wasn't going to work.

Interviewer

Ok yea so you mean from a previous session where a movement hasn't worked properly for you and you knew you had to come and do that movement again so you think about it a little bit?

P08EX

Yes. Yes. Yes.

Interviewer

I see yes but then we took those out.

P08EX

You did yes but just on the last…

Interviewer

Yes because I wanted to see if we could crack it to be honest. We took the lunges out on the last session

P08EX

Yea. Just the last one I think. So if I come back you will put them back in won't you.

Q.10. Were you conscious of the movements being conducted during your training session? Where was your attention? Did you enjoy the experience? Worried about performance? Did you feel in control?

Interviewer

I think I will to try and if it still doesn't work then I would probably change it over to another movement. So were you conscious of the movements when you were playing a game? So if you can imagine yourself starting up and you're in the game. Are you aware you are doing the movement or is your mind mainly focused on the screen and what you need to do to drive the game?

P08EX

Oh no I was aware I was doing the movement and thinking am I doing this movement correctly? I tried my best to do it correctly but yes I was aware of the movements as well as concentrating on what we were trying to achieve in the game.

Interviewer

Right in the game. Did that make you feel more capable of playing the game? Just because as you know you had to think about playing the game and performing the movement at the same time so it's almost like performing a dual task. Did you feel like that was slowing you down in the game? Or did you feel you were able to play the game at a good speed anyway?

P08EX

I don't think it slowed me down. I don't think so. The ones where you had to get the brain in action. Until you got going I felt…

Interviewer

It's almost transitioning from one game because I know after the "Grab" game, from my observation, I had seen you going straight into a game where you had to think a bit more with the brain than just the movements. So the movements are quite simple but it was taxing the brain a bit more. I don't know if you were worried about performance at all?

P08EX

Probably. Probably and I know you're there on your own. But I was maybe thinking at times, are the other participants doing better than I am?

Interviewer

Right. That's very competitive as well isn't it?

P08EX

And then if I couldn't remember, does Robin think this is old age creeping in here.

Interviewer

Right so it's almost like self-thoughts in a way. It's almost like it's ensuring that you are performing quite well isn't it?

P08EX

Yea. Does he think I'm stupid? Haha no I know. I know. These oldies.

Interviewer

No he doesn't haha. Not at all. Ok so you thought your attention was on both the screen and the movements.

P08EX

I did. Yep.

Interviewer

And you were worried about performance a bit because you were comparing yourself with other participants and what I might think of what you are doing.

P08EX

Yes. Is that normal?

Interviewer

Yes if someone was observing me training I would be definitely be aware of what they might think whilst I was doing the training definitely or the other people that do the training if they were better than me, worse than me. But you don't get to see that do you?

P08EX

No. No. I know it's not... for example going back to the yoga class. The teachers would always tell you you're doing this for yourself. It doesn't matter what other people do. But you can't… maybe that's just human.

Interviewer

Depends how competitive you are as a person I guess.

P08EX

Yea

Interviewer

Even if they are saying that, you're still having a sneaky look out of your eyes saying "oh she can do that…"

P08EX

Yea oh she can bend and I can't. Yea that's true.

Interviewer

That's alright though. Is that motivational as opposed to detrimental during the training do you think?

P08EX

I don't know because in yoga you have got a real expert next to you… bent or doing the lotus position and you cannot do that… oh.

Interviewer

So sometimes you might feel a bit bad from it or? Demotivated?

P08EX

Yea.

Q.11. How do you feel the training program impacted your level of fatigue? How did this impact your motivation to train?

Interviewer

Ok so how do you feel this training programme has impacted your levels of fatigue? Your Pep? Your energy levels? Do you feel more or less energised since you have done it?

P08EX

I think I feel more energised because you know like when you have been to a gym session or whatever and I think you feel a bit like… oh I'm high because you've done a little bit of exercise.

Interviewer

Ok. Brilliant. Do you think that motivated you to train harder? Or anything like that?

P08EX

I hope so… because when I did come back every week.

Interviewer

From the first session to the last session, where over the six weeks you had been doing it twice a week for 30 minutes each time. So by the sixth week did you feel like you had more energy? Or less energy? Going about your typical daily activities as well did you have more energy? Not just in the training session I mean.

P08EX

I think it does definitely energise you. Yea I do feel as though I had more energy.

Interviewer

That's why I remember when you would come in for a session I would ask if you had been out for your walks the day before as you said you used to.

P08EX

Yea

Interviewer

Are you still doing those walks then?

P08EX

Yea.

Interviewer

Are you doing anything to replace coming to the sessions?

P08EX

Not yet.

Interviewer

Not yet ok.

P08EX

But it's only been last week haha.

Interviewer

I know it's only been a week haha.

P08EX

Now come on. No. Not yet but we will walk.

Interviewer

Would you think about going to something now that you'd had this training for six weeks and now maybe you want to do something that is going to keep those energy levels up?

P08EX

Well apart from me assuring my friends that I'm back at yoga once I've finished this. I can't see myself going back to gym sessions just because it's been so long and maybe I'm getting too old.

Interviewer

Right. Well you're never too old for a gym. I was in the gym this morning and I saw quite an old gentlemen, in his late 70's I think and he was just... I mean he wasn't doing very heavy weights but he's in there and he is amongst it all so…

P08EX

Yea.

Q.12. Did the training program feel negative in any way in terms of your self-thoughts? (Negative self-talk) Did you feel absent during the program? Could you sleep ok? Slowness of thoughts? Angry?

Interviewer

It's definitely motivational to see that as well. I know we mentioned it briefly before but do you feel the training program felt negative in anyway in terms of your self-thoughts? So what other people might think of you? Or how well they performed compared to yourself?

P08EX

Yes and you know I suppose the negativity, thinking about, say the lunges where I felt as though I wasn't achieving. Although you were encouraging me and telling me that I was doing the movement correctly. So that was quite good.

Interviewer

So this was prohibiting you from thinking more negatively?

P08EX

Yea your encouragement, because of that, I thought heavens I'm not doing this right.

Interviewer

So do you think that maybe if you had been on your own in an environment where I wasn't there it would have felt a bit worse or?

P08EX

I think I might have given up.

Interviewer

Stopped playing the game?

P08EX

Yea just thinking oh well this isn't going to work.

Interviewer

How would that compare with seeing an expert in yoga next to you doing movements a lot better, a lot more flexible and a lot more moves. How do you think that would compare? Do you think it would be the same sort of feeling or?

P08EX

Well if I… whenever I've been in that situation in yoga you've still got to try.

Interviewer

Yea you've still got to do it and try because there's other people there?

P08EX

But there's other people there haha and the teacher.

Interviewer

Yea exactly but if you were on your own just with this you might give up instead.

P08EX

You might just give up. Yea. Yea.

Interviewer

Ok that's good to know. Any issues with sleep at all during the six weeks?

P08EX

No.

Interviewer

I mean I don't know if you suffer from any sleep issues anyway. I just mean is there any changes in your sleeping patterns?

P08EX

No changes. No.

Interviewer

Any sort of anger? Apart from at the lunges haha and me for making things harder.

P08EX

Haha no. My husband might not say that. No changes as far as I know.

Interviewer

So now that you are going about your daily activities, even though we've just talked about a fall you had last week. Yesterday.

P08EX

Yesterday.

Interviewer

Do you still feel more confident now? Like you mentioned you did feel confident… do you feel weary about going out or do you feel like you might fall over? Apart from Marks and Spencer's on the floor yesterday.

P08EX

No I don't think I'm going to fall over. But going back to Marks and Spencer's

Interviewer

But you didn't think you were going to fall over then either.

P08EX

Oh no just swoosh, happened.

Interviewer

It just kind of happened.

P08EX

But I don't think I fell.

Interviewer

Well it's a fall. I'm sorry to say but it's the definition of a fall. It starts off as a slip

P08EX

Yes I went onto some liquid.

Interviewer

Yes so it started off as a slip and ends in a fall from what you've described to me.

P08EX

Right.

Interviewer

So it starts of as a slip which incurs a fall, which is basically resting on a lower level than what you were originally.

P08EX

Ah yes I remember that in your initial email.

Interviewer

In the email yes.

P08EX

Yes I was on the ground haha.

Interviewer

Ok. So it was a fall but that's because the floor was wet and they should have put a sign up.

P08EX

Yes.

Q.13. Can you tell me how you feel when you go about everyday activities? Are there any fearful moments you have or concerns when you are out and about? (falling over)

Interviewer

So apart from that have you had any fearful moments when you've been out and about?

P08EX

No.

Interviewer

Nothing at all.

P08EX

No. I may get more fearful as I think I said at the beginning when it comes to winter. That's my worst fear as I've got older.

Interviewer

I hear a lot of people say this. Everybody tells me this.

P08EX

Just it's slippy, icy and frosty.

Interviewer

Icy and frosty and you have a look around just before you leave the house.

P08EX

Yes and you don't walk as you would walk because you think you're going to fall. I mean when you say everybody says this, do you mean everybody older or just everybody?

Interviewer

A lot of people I have been talking to have been saying the same thing, in this study.

P08EX

Right.

Interviewer

So you are not alone. It's true.

P08EX

Well that's good to know.

Interviewer

Yea so everyone knows… they say oh it's a bit slippy out today but you have to stay on the ball don't you.

P08EX

Yes.

Q.14. How confident are you that you will not lose your balance or become unsteady in everyday outdoor and indoor activities now that you have received some balance training? E.g. Up and down stairs? Standing on a high surface? Escalator in shopping mall? Quick turning?

Interviewer

So now how confident are you now that you will not lose you balance or become unsteady in everyday or outdoor activities? Apart from in the winter. It's almost saying the same thing. It's the opposite end of being fearful of falling over. So you are confident but maybe less confident in the winter because of the icy and the frost…

P08EX

Yea the weather conditions, but confidence in the home for example, you know I have a little step thing if I need to go to a higher cupboard or wardrobe

Interviewer

You have no problems getting a chair out and standing on a chair?

P08EX

No. I mean my husband does sometimes tell me off but I feel confident.

Q.15. Is there anything else that this training has done for you that you would like to comment on?

Interviewer

Ah that's ok then. Ok brilliant. So yea, is there anything else you want to say that you've enjoyed or say about exergaming to train balance?

P08EX

Just that I think it's a good idea. It would be good to see it put into practice and I do think your encouragement helped.

Interviewer

So yea having someone there to observe and maybe tell you how to drive the game a bit better with the movements?

P08EX

Yes with the movements.

Interviewer

Yea? So a bit of support would be useful. Also you did mention at the start about having this environment that you had to come to which makes you almost have to be motivated. You know if you go into a sports centre where you see lots of people there and so would you say that's motivational?

P08EX

Yes. Yes.

Interviewer

Because obviously there's a lot of young adults there as well and they're all doing their stuff and you found that motivational as well.

P08EX

Yea. Yea.

Interviewer

Brilliant. So the environment makes a difference as well.

P08EX

And I know we've compared it to the Wii™ game at home but then would you do it as much? I don't know. If you're enjoying it.

Interviewer

Ah that make sense, yes. So you would definitely come back and do it again?

P08EX

Yes I would.

Interviewer

I mean I've got you on the list already so if it does happen haha.

P08EX

You'll make it harder haha.

Interviewer

Right well we will leave it there then.

P08EX

Yea.

Interviewer

Thank you.

Interview 1

Interviewer/Transcriber - Robin Tahmosybayat

Participant: P08SS

Location: Deckham Village Hall, Gateshead
Time: 20 minutes

Q.1.What are your thoughts on the training program? Did you enjoy it?

Interviewer

Ok so I just want to ask you some questions on… what are your thoughts on the training program? Have you been enjoying it?

P08SS

I've enjoyed it very very much.

Interviewer

Yea?

P08SS

Very helpful.

Interviewer

Yep ok. In what regard has it been helpful for you?

P08SS

Well… just the way it's all put to you really. You just get used to Richie and he explains everything.

Q.2. Anything specific that stood out about the training program? (Favourite game? Favourite movement?)

Interviewer

Right brilliant ok. Anything in particular that's stands out when you have been coming to the classes? Like a favourite part of the class? Like the education part or …?

P08SS

Yes the friendliness of everybody you know… I've got to know a lot of people

Interviewer

So you didn't know anyone from this class before coming to this class?

P08SS

No no not at all

Q.3. How do you feel after a particular session during the training program?

Interviewer

Ok brilliant. So give me an example of how you feel after a particular session? So at the end of the hour once you have done the balance training, how do you feel in yourself?

P08SS

Quite good really. Just the bother of waiting for taxi's to get home and things like that you know. I feel it has done me good when I've done the exercises.

Interviewer

The need to get a taxi to drop you off and pick you up for the class is not something that everybody would necessarily do and you're still doing it anyway.

P08SS

Exactly yes I still do it anyway. You see it costs us, well I have got a taxi card and I get three pounds off any journey which is a good thing. It would cost me nine pounds each way to come and go but it's like six pounds instead so that's alright.

Interviewer

Yea. That’s alright.

P08SS

I mean that’s three pounds off each way

Interviewer

Yes that adds up really doesn’t it?

P08SS

Oh yes.

Q.4. Any aches or pains that have gone away? Have come back?

Interviewer

We’ve done six sessions so you are making some savings on each journey. Brilliant. So have you had any aches or pains that have kind of gone away? So I know we are only half way through this program, but from when you started, we’ve all got aches and pains that aren’t going to go away but have you felt like there’s been any change in the pain at all?

P08SS

No not really. I am very very fortunate. I don’t have aches and pains. Since I did this hip I thought I would have a lot but I haven’t. None whatsoever.

Interviewer

Like what Richie was saying in the class before. Do you feel like it’s more mobile? Like you can do a bit more with it now than you could do at the start?

P08SS

Yes. The only thing really is standing on that right leg. I can’t… you know he says kick that leg out. I can’t stand on this leg to kick the left leg out.

Interviewer

Yes that’s a restriction from the operation?

P08SS

Yes. Yes.

Q.5. How does this compare to other types of training programs you have been a part of?

Interviewer

Right ok. So have you been a part of any other training programs?

P08SS

Not really. I used to go to the gym a good few years ago when I was a lot younger.

Interviewer

Ok but you've not done anything recently in terms of balance training or anything like that?

P08SS

No. No.

Interviewer

Right ok. So this is your first time doing something like this. So would you say that the movements you have been doing in these classes you would have done in any other aspect of your life at all?

P08SS

Yes that's it. The exercises we do aren't the exercises you would do in a gym. They are special exercises aren't they.

Interviewer

They are focused on balance?

P08SS

Yes they are focused on balance and confidence.

Q.7. Would you do it again?

Interviewer

Right ok. At the end of the program do you think you would do it again… if it was available?

P08SS

If it was available and if I could get somewhere nearer really. That's the problem.

Interviewer

You are over by Sunderland aren't you?

P08SS

No it's nearer to Washington.

Interviewer

Right well I mean either way something a bit more close wouldn't be as far away to go and come back but the actual content of the classes though is worthwhile is it?

P08SS

It is worthwhile I agree with you.

Q.8. What would you change about training program (Exergaming, Staying Steady) console, game) to make it more engaging?

Interviewer

Ok so I am going to ask you some questions now in a bit more depth. So what would you change about the staying steady classes to make it a bit more engaging? I mean you have 15 people in a class maximum. Is there anything that you would change about it?

P08SS

Nothing that I could think of. No I think it is ran very well.

Interviewer

Ok, would you say this method of training balance was safe?

P08SS

Yes because Richie always says if you can't do it, don't force yourself. You know… it's good.

Interviewer

In terms of in the class, always it's you talking with Richie. He's showing you all the movements you need to do. Do you feel like that's enough? Do you think that's all you need?

P08SS

Oh yes because week by week he's taking it more in depth hasn't he. Yes. Yes I do.

Q.9. What are your perceptions on safety of using this method (Exergaming/ Staying Steady) to train balance? (Self-efficacy) Were you anxious at all during training? (Anxiety)

Interviewer

Ok. Brilliant. So did you feel anxious at all during any of the classes? So maybe a movement that you didn't feel quite confident doing or?

P08SS

That one where the rubber bands were on the floor and you had to walk backwards and I was a bit concerned in case I wasn't doing it right but you know that's just one of these things isn't it.

Interviewer

That's it I mean we don't always walk backwards down the street do we

P08SS

We don't know.

Interviewer

But it's almost like he's prepping you for everything.

P08SS

Exactly yes.

Q.10. Were you conscious of the movements being conducted during your training session? Where was your attention? Did you enjoy the experience? Worried about performance? Did you feel in control?

Interviewer

Ok. So were you conscious of the movements you were doing?

P08SS

Yes. Yes.

Interviewer

So in your session, where was your attention? Was your attention on the movement you were doing? Was your attention on listening to Richie? Were you focusing on stepping here or focussing on going up on your toes? Where was your attention?

P08SS

Definitely on the movement that I was doing. Yes.

Interviewer

Ok brilliant. Did you feel in control of that movement whilst you were doing it?

P08SS

I felt in control but I knew for a fact that I wasn't doing it the way I should.

Interviewer

What do you mean?

P08SS

You know, when you went back and if you stepped on the rubber band, which I mean a few of us did that.

Interviewer

Yes I think he was expecting that. I mean that's why everyone here isn't it.

P08SS

Yes.

Interviewer

Right ok. So were you worried about your performance at all?

P08SS

Not really. Concerned yes but not worried no.

Interviewer

Right ok and you say you have enjoyed the experience of the class?

P08SS

I’ve loved the class yes.

Interviewer

Fantastic. That’s good to know.

P08SS

They are lovely people. You two are nice lads.

Q.11. How do you feel the training program impacted your level of fatigue? How did this impact your motivation to train?

Interviewer

Thank you very much. How do you think the training program impacted your level of fatigue? Maybe in one class? Or from the beginning of the program compared to now? Do you think your level of fatigue has improved?

P08SS

It has improved because at first I felt sometimes a wee bit tired but going off now I don’t.

Interviewer

Brilliant. Has that impacted your everyday activities? Do you feel like you just don’t get out of breath as much or? How has you fatigue changed?

P08SS

Well I think it has improved. I know for a fact that I am walking better. I’m definitely walking better.

Interviewer

Right ok, brilliant.

P08SS

When I go over to church on a Sunday I just take my stick. My elbow crutch. But if I go to my ladies club I’ve got a four wheel walker and I feel more confident because it’s further to walk. I can put my handbag in the seat thing. I’m more confident with the four wheel walker going any distance. Now I went to Newcastle on Saturday with my twin granddaughters and I took the four wheel walker and I felt that much easier getting about. You know because I’ve got two crutches but I just use the one. The thing is, this… (points to left forearm). From there to there is numb because… can you see there?

Interviewer

Yes I can see yes.

P08SS

I sliced my arm right from there to there. I had a nasty gash. I was going into the garage to put some weed killer on the um… chippings in my garden and coming out I tripped. You know on your garage door there are two steel sides well my arms just went down and it literally sliced from like there, well you can see.

Interviewer

Yes I can see it has gone all the way round there hasn't it.

P08SS

I was lucky I didn't lose my arm. From there to there it is numb but that side isn't.

Interviewer

So it must have gone through one of the nerves or something.

P08SS

Oh yes it did. It um… what do they call it..? Um… he said I'd um…

Interviewer

It wasn't a fracture was it?

P08SS

Oh no.

Interviewer

Severed?

P08SS

Severed. Severed. He said I'd severed the artery and it wasn't bleeding, it was gushing.

Interviewer

Well if you sever an artery its straight away. Well luckily you still have your arms so that's alright.

P08SS

Well they said I might lose my arm but I can use my arm, I can use my fingers.

Interviewer

As long as you're still using it then that's alright.

P08SS

The numbness doesn't bother me… because I can still hold the crutch. You know… for all I cannot feel there, I can still hold the crutch.

Interviewer

Right yes and you've always got the other hand to use for the crutch as well. So I mean it sounds like it's been a pretty good experience.

P08SS

Very good experience. I cannot say any other.

Q.12. Did the training program feel negative in any way in terms of your self-thoughts? (Negative self-talk) Did you feel absent during the program? Could you sleep ok? Slowness of thoughts? Angry?

Interviewer

Fantastic. But has there been any negative way at all in terms of your self-talk or your self-thoughts that have influenced you in the training program? Did you feel negative in anyway whatsoever at all? You might have had a task that you couldn't quite do as well as other people? Or any self-doubt? Any slowness of thoughts? Any anger? Have you felt absent at all from the program?

P08SS

No I cannot say I have. You know when he tells you to move your feet and stand behind the chair, I feel like I can't move my feet up as high as everybody else but I still move them.

Interviewer

I must say I have been in quite a few of the classes and he does say it's about what you can do, doesn't he?

P08SS

Exactly. Yes.

Interviewer

He kind of reiterates that you don't compare yourself as such.

P08SS

That's true.

Interviewer

So I think he kind of… Do you think Richie helps stop that negative self-thought by reminding you that this is about what you can do?

P08SS

Exactly yes.

Interviewer

Is there any other way that he might help with these sorts of things in the classes like… does he help with your self-confidence or?

P08SS

Yes… I still would like a bit more confidence but that's my own thinking.

Interviewer

In what way?

P08SS

Um… I have never yet been on a bus myself and I know I think I could do it.

Interviewer

Is it since the hip?

P08SS

Yes it is.

Interviewer

Right ok.

P08SS

It's not the getting on the bus. It's the fear of getting off the bus. You know… I should maybe try it. I've never done it yet but um…

Interviewer

Yes I would say that's something that um…

P08SS

I mean Richie did give us that card thing. You know you could use that card, yes.

Interviewer

Ah yes so they can lower the bus as well. They know. You just show them the card and the bus driver knows he not going to move until you are sorted.

P08SS

Until now I have never been on a bus myself. I've got the twin granddaughters, I've told you.

Interviewer

Yes. Yes.

P08SS

They come all over with me. They are very good. My son takes me shopping in the car. He takes me shopping. We go to the galleries. When we get to the galleries I go on my stick but I put my stick on one of the trolleys and the trolley supports me. So I do my own shopping around the galleries and he says he will pick me up at such and such time and he brings me up.

Interviewer

So that's independence as well isn't it.

P08SS

Yes.

Interviewer

Right ok brilliant. So not really any negative feelings as such because the class is quite positive isn't it?

P08SS

It is. It is.

Q.13. Can you tell me how you feel when you go about everyday activities? Are there any fearful moments you have or concerns when you are out and about? (falling over)

Interviewer

So you just mentioned there that you go out and you do your everyday activities and you're alright getting to the galleries and you go and do your shopping and your son picks you up. So when you are out and about, do you think before the program you would have been a bit more fearful?

P08SS

I would. Yes.

Interviewer

Would you say this fear has kind of lessened now?

P08SS

It's definitely lessened. Definitely yes.

Interviewer

Ok. Would you say that's because of the balance training you have been doing? Or would you say it's just being with other people who are doing a similar thing?

P08SS

Well it's a mixture of both really but I feel the balance has improved. I would like to improve more, but I think I'm getting there. I think it is gradually improving.

Interviewer

Fantastic. Ok. So you say you used to have fearful moments when you were out and about?

P08SS

Yes.

Interviewer

So coming to this class, has that kind of reduced?

P08SS

Exactly. Yes. Like Richie says, if you think you can do it and that's what you should do. Not "I cannot". You should think "I can".

Interviewer

Exactly. So it's almost like changing the way you think about things up here (points to head).

P08SS

Yes. Yes.

Q.14. How confident are you that you will not lose your balance or become unsteady in everyday outdoor and indoor activities now that you have received some balance training? E.g. Up and down stairs? Standing on a high surface? Escalator in shopping mall? Quick turning?

Interviewer

Ok. So how confident are you that you will not lose your balance or become unsteady when you're outdoors now? So maybe if you're going to do the shopping or if you're out and about? You've got your support when you need it. So would you say you feel more confident now? Or would you say you feel less confident?

P08SS

A little bit more confident but I would still like to be more confident.

Interviewer

So is there anything you think you could do to help build that confidence?

P08SS

Well just practice more. Practice makes perfect.

Interviewer

So what kind of things would you practice to kind of build that confidence?

P08SS

Well I get my walker and have a trip over to my neighbours and I go round to my other neighbours. I can do that on my own, you know, just with a stick. As I say I think that's gives you confidence because you're doing it on your own.

Interviewer

That's it so it's all about getting out and trying.

P08SS

Yes.

Interviewer

Giving it a go. Doing things again and again.

P08SS

Yes. Yes.

Interviewer

Maybe challenging yourself. A little bit further next time?

P08SS

Now a friend of mine, it’s next month actually, we’re going down to St. Anne’s. Just on a weekend thing. A three-day thing with Chris cooper coaches.

Interviewer

Ok. So that’ll be like sort of a new environment?

P08SS

That’s a new thing. So we went to Bridlington in September and I managed quite well. I take the walker but getting about I manage alright yea.

Interviewer

Brilliant. Yes that’s fantastic.

P08SS

I’ve stopped the injections now. I was on the injections.

Interviewer

Were they steroid injections?

P08SS

No, forsteo

Interviewer

Ok I’m not sure what they are.

P08SS

Apparently, the hospital put me on them. He said they are very expensive injections. He put me on them for eighteen months.

Interviewer

And what is the purpose of them?

P08SS

Apparently it’s to build the bone up.

Interviewer

Right ok.

P08SS

It doesn't make you feel any different in yourself but apparently it builds the bone up.

Interviewer

Right ok.

P08SS

And I just finished them last Friday. I had to inject myself every night and I go back to the hospital to see the consultant on the twenty-third of this month.

Interviewer

Right ok. To see what they say? To see if the bone has been building up?

P08SS

It was the hospital that advised these staying steady classes.

Interviewer

Yes it's the falls clinic isn't it?

P08SS

Yes.

Interviewer

Right so you found out about the classes in the falls clinic?

P08SS

Yes I did

Interviewer

Ok brilliant. So you're feeling a bit more confident yea? There weren't any elements of depression.

P08SS

No No.

Interviewer

Fantastic. You were quite aware of the movements you were doing in the classes. You think your levels of fatigue have kind of improved now.

P08SS

Definitely they have yes.

Interviewer

Your confidence has improved a bit but you'd like a little bit more confidence you say?

P08SS

Yes.

Interviewer

Ok, well I mean this course, obviously your only half way through this actual course

P08SS

We are.

Interviewer

So you've still got about eight weeks he (Richie) mentioned before, to go.

P08SS

Yes. He said eight weeks to go yes.

Q.15. Is there anything else that this training has done for you that you would like to comment on?

Interviewer

Ok. Is there anything else that you'd like to say about this type of training that it's done for you?

P08SS

I cannot think of anything of hand. Just that I'm very satisfied with it and I look forward to the Mondays coming you know. I do yea.

Interviewer

Fantastic.

P08SS

I've only missed the one. It was because I was having something delivered. I wouldn't care I could have been. They delivered it before the time of the class.

Interviewer

But you never know, do you.

P08SS

You never know. That's true.

Interviewer

Ok brilliant. Well thank you for sitting down and talking with me

P08SS

You are welcome Robin.

Interview 2

Interviewer/Transcriber - Robin Tahmosybayat

Participant: P04SS

Location: Deckham Village Hall, Gateshead

Time: 34 minutes

Q.1.What are your thoughts on the training program? Did you enjoy it?

Interviewer

So I'm just going to ask you some initial questions first. What were your thoughts on the training program so far? Have you been enjoying it?

P04SS

I've enjoyed it. Yes I've enjoyed it.

Interviewer

Anything in particular that's stood out about it?

P04SS

I cannot think of anything specific that stands out. It's just that I fell it's been of benefit you know. I think it's helped me with my confidence really and my muscles and no doubt it's helped my bones as well.

Q.2. Anything specific that stood out about the training program? (Favourite game? Favourite movement?)

Interviewer

Right. Brilliant. So is there any favourite part of the experience of coming to the classes? Any favourite movements that you've enjoyed learning more about or? Getting up off the floor?

P04SS

Haha that was… I found that really difficult and I was surprised I did it so easily.

Interviewer

What made you feel so surprised?

P04SS

Because I've had that many falls this year and I haven't been able to get up. So it's made me lack confidence in my ability to… in myself, you know?

Interviewer

So this is like a turning point now that you have this… now that you are an expert.

P04SS

Haha.

Interviewer

So now that you have the knowledge in knowing how to get back up again, it's kind of helping? Obviously it's not going to come back all in one session, your confidence, but that's why the course is over twenty weeks essentially isn't it?

P04SS

Yea. Yea.

Q.3. How do you feel after a particular session during the training program?

Interviewer

Ok so could you tell me how you feel about your balance after a particular session?

P04SS

I feel ok. I feel pretty good afterwards. Well at least I've made an effort to do something rather than just think I'm in this predicament and I can't get out of it and just give up virtually like what Richard said. It makes you feel like you've got to get up and do something about it. It's no good just lying there and playing dead.

Interviewer

Because it always get worse doesn't it?

P04SS

That's right. It's been explained that it actually helps your joints and your bones which I didn't realise. That it strengthens your bones exercising them. I never knew that. I knew it strengthened your muscles but it actually strengthens your bones.

Interviewer

I mean your bones… everyone thinks that… when you say the word bone, everyone envisages this white sort of material that is solid but really your bones when they are inside your body, they are full of blood.

P04SS

That's right yes.

Interviewer

They’re red. They’re red and blue and there’s blood going everywhere and they are not actually white. I mean yes the calcium part of the bones are white. So that’s why they change depending on what pressure or what kind of things you do so by doing these sorts of exercises.

P04SS

Yea it certainly helps yea.

Q.4. Any aches or pains that have gone away? Have come back?

Interviewer

Ok brilliant. So have you had any aches of pains at the start of the program that have gone away by now?

P04SS

At the start of the program I felt my arm muscles must have been weaker than I thought. I had a lot of stiffness in my joints.

Interviewer

Was that before you came to these classes?

P04SS

No. That was when I started to use the band.

Interviewer

Right ok. Ok. So it was the resistance bands that you were using?

P04SS

Yes

Interviewer

Right ok.

P04SS

And I didn’t realise because I’ve been stuck in the bath a few times. Actually I don’t even get in the bath. I’m too scared. But I couldn’t get out this day and that really freaked me out you know (nervous laughter). It’s just one of those things.

Interviewer

Is that a feeling of being stuck and not being able to…

P04SS

Yea

Interviewer

Yes I understand that.

P04SS

So my daughter had to come and lift me from behind. Well she actually had to get in the bath with us (nervous laughter). It sounds funny when I'm saying it now but at the time I was in tears because I was in there for ages.

Interviewer

Right yea.

P04SS

So Richard was saying that if you use your muscles more. Strengthen your muscles in your arms, it helps you push yourself up.

Interviewer

Exactly yes.

P04SS

I still don't get in the bath though because I've got a bath seat.

Interviewer

That's a confidence thing that though?

P04SS

Well it's not so much confidence. It's when I get out of the bath seat. Because it's so high. They put the seat over the handles on the bath and I can't really swing… this leg feels a bit dead. I know he (Richard) said I was using it today but at some points it feels like it won't go where I want it to go and I keep catching my feet on things. So trying to get out of the bath I had to like swivel round and I got stuck in between the sink and the bath. So it meant I felt I was going to fall and that hasn't, I haven't got that confidence back yet.

Interviewer

Right ok. It does kind of sound like you are dwelling on that because it has happened.

P04SS

Well I've been in a couple of times and it's happened each time I have been in you see.

Interviewer

Ok. Right so it's a repeated thing that's kind of happened.

P04SS

Yea. Yea.

Interviewer

Ok.

P04SS

So I'm thinking about maybe trying to get a loan to get a shower put in. But anyway…

Q.5. How does this compare to other types of training programs you have been a part of?

Interviewer

Right ok, that's fine. So is this the first time you have been to a balance training program?

P04SS

Yea. When I was having the falls I went to the doctors and I said I was, like, unsteady on my feet and it had worsened over the last year. He said I will send you to the falls clinic. So I was going to an exercise class there and the doctor in charge didn't seem to think it was doing me much good at the time because I was still walking badly and I still walk with a gait and I'm finding it difficult to get on buses and get up steps but he suggested this class. So I said oh I will try.

Interviewer

Did you have to pay for the falls clinic?

P04SS

No. No.

Interviewer

No. Right ok. How do the exercises you were doing in this class, how does that compare to the exercises you were doing at the falls clinic?

P04SS

Well it's longer.

Interviewer

Here's longer?

P04SS

Yes it was only six weeks there I think. I think it was about six weeks and it was only maybe half an hour. Well these (staying steady classes) are better. Well I think they are better anyway.

Interviewer

Ok. Were you at the falls clinic just before this (course)?

P04SS

Yes. Just a couple of weeks before.

Q.7. Would you do it again?

Interviewer

Right ok. So would you come and do this again at the end of the twenty weeks?

P04SS

I would yes.

Interviewer

Ok. I mean I don't think you're allowed to but…

P04SS

I know. I know I don't think you are.

Interviewer

But if there was something else that was very similar in nature. I think that's what your home work is for this week actually.

P04SS

Yea I've got to find somewhere nearer home yea.

Interviewer

But it's almost like continuity isn't it?

P04SS

I try to do it at home but I've been… the more you're away from the classes, when you've got encouragement from other people and your teacher obviously… you drift into bad habits again. You're like "oh I cannot be bothered" or "I'm too tired"

Interviewer

I see what you mean. I mean I get that when I don't go to the office sometimes a feel less motivated to work. What kind of effect does that have then with other people being in your life? Can you see other people doing it (balance training)? Other people in your situation?

P04SS

Yea it's the same with anything isn't it really? Whether it's Weightwatchers or? Once you start going…

Interviewer

Weightwatchers or balance training or anything that you're struggling with, if you see other people doing the same thing, it's motivational isn't it?

P04SS

It is. Yes. Definitely. It encourages you.

Q.8. What would you change about training program (Exergaming, Staying Steady) console, game) to make it more engaging?

Interviewer

Would there be anything about this training program that you would change to make it a bit more engaging?

P04SS

Well there was one week we came and they offered us a cup of tea and we had a bit of a chat with one another and that was lovely because it got us chatting about maybe getting a bit more friendly with others and that's helpful. Well I thought it was anyway. I think it would be lovely if we could just…

Interviewer

Do it on weekly basis maybe or something?

P04SS

Yea maybe just have a cup of tea and a little bit of a break and a chat. Just for ten or fifteen minutes.

Interviewer

During the class you mean?

P04SS

He did it, I think, just after the class finished. It was just after week three or something like that. So he said "would you like a cup of tea?" and I thought it was going to be every week and I was gutted when I found out it wasn't (laughs).

Interviewer

Ok so about the actual training itself. Do you think it's sufficient what he has been doing in the classes? Or do you think there could be something that would make you engage a bit more with it?

P04SS

I don't know. I know different people try to give their little bit of input. It's difficult to find out maybe how to help people as individuals because sometimes people are shy

Interviewer

You mean because it's like a group class?

P04SS

Yea so they're not given their own little input. I think I've left my scarf in there (other room). Oh no it's here.

Interviewer

Ok yes so this is a group class and you've got one teacher to about fifteen people in a class. Do you think you would prefer one on one? Or do you enjoy the group ideally?

P04SS

Oh no it's nice with a group. It's nice with the group but I just think maybe a little bit extra, sort of like, time maybe? Maybe like a bit longer. Just because it's only… I mean sometimes… the first time we came it lasted for quite a while.

Interviewer

Yea so the first one where you were doing the assessments and everything as well?

P04SS

Yea. Yea and as I say after about week three, we had this cup of tea and discussion but it would be nice to have a little bit feedback from each person to see how they're doing on an individual basis.

Interviewer

Right ok and so you can compare that with yourself or..?

P04SS

Well it's just nice…it's quite stimulating to see how other people are dealing with things.

Interviewer

And that would help you engage more in the class do you think?

P04SS

I think so. I like people you see. I like to know how people feel and how they react to things and how they're coping in the hope that you can help them, you know, not just always bout me.

Q.9. What are your perceptions on safety of using this method (Exergaming/ Staying Steady) to train balance? (Self-efficacy) Were you anxious at all during training? (Anxiety)

Interviewer

Right ok. That makes sense. So what are your perceptions on safety of using classes to train to improve your balance? So do you think it's a safe method to train? Like so staying steady is a balance training class, so you come here and then you do your training. Would you say this is a safe way to do that training?

P04SS

I think so. Yea. It's pretty safe yea. Sometimes he will tell you to do something and it's like yea that's alright… like for example when he said like "now you know how to do it" but it depends where you fall, how you fall. As that one person said, if you hurt yourself and… so sometimes I just think it would be nice to engage with finding out a bit more about people and how he can help them, you know.

Interviewer

Right ok.

P04SS

I'm waffling on here.

Interviewer

This is exactly what I want. I want you to waffle on. No it's good. It's good for me. So did you feel anxious at all during any of the training sessions?

P04SS

I felt a little bit anxious at first when I didn't know anybody. A little bit yea.

Interviewer

Ok so almost like a preliminary thing?

P04SS

I always think the best way to deal with things is to think about others and forget about yourself and… you know, that helps you really to concentrate on how other people are feeling.

Interviewer

Yea so I guess that in return they will kind of concentrate and see how you're feeling as well.

P04SS

Well I suppose so yea.

Interviewer

Ok so any particular movement or any part of the class that gave you anxiety?

P04SS

One of the ones was getting down on the floor (nervous laughter).

Interviewer

Right ok. Because that's almost like closely replicating falling as well.

P04SS

Yea. Yea and when he had things on the floor and he said you had to step over them or side step them.

Interviewer

The mini-obstacle course?

P04SS

Yea and then one day he said "go backwards" and I thought "Ahh". I found that really difficult because it was just a bit scary really because, you know, when you've had that many falls, you just start to be a bit unsure of yourself really.

Interviewer

So it makes you a bit weary of doing things?

P04SS

It makes you a bit weary yea. I keep thinking “I cannot do it. I cannot do it”.

Interviewer

Yea. So that’s what you tell yourself but I guess that’s why he is getting you to do it. So he gets you to do this and practice so you see and he gets you to think when do I walk down the street backwards? When do I go and step over things backwards? So this is a situation that you don’t really tend to do every day but I guess he’s helping you try and prepare for that situation.

P04SS

Ah I know. I know that.

Interviewer

But yes that’s interesting to know. So that sort of thing. Doing things you wouldn’t normally do would give you anxiety?

P04SS

Yea. Yea.

Interviewer

Ok. Was there anything given in the class to help you overcome that anxiety?

P04SS

Just that it was good that he got us to do them and not just tell us. He said like this is what you do but actually getting you to demonstrate it yourself. It helps you.

Interviewer

Yes as in giving a go yourself is the best way to learn.

P04SS

Yes. Yea. Yea. I don’t know if I am giving you right answers or wrong answers here.

Q.10. Were you conscious of the movements being conducted during your training session? Where was your attention? Did you enjoy the experience? Worried about performance? Did you feel in control?

Interviewer

It’s not about what’s right or wrong. Whatever you want to say, you say, alright? So were you conscious of the movements you were doing in the session? So for example, he says “right so now we are going to do the balance part of the session so you have to start off behind your chairs, try not to use your chair if you don’t need it” because he wants you to use your muscles and to focus on the balance.

P04SS

Oh yes. Yes.

Interviewer

Where was your attention during these exercises? Was your attention on what you were doing? Was it on what other people were doing?

P04SS

Oh no it was on what I was doing really. I was more concerned about hanging onto something in case I was going to fall over. I was worried in case… you know when he was saying stand behind your chair and you can use your chair but one of the exercises he told us to do was to make our arms go and legs go at the same time and I found that really hard.

Interviewer

Like the coordination of the arms and the legs?

P04SS

The coordination yea.

Interviewer

What was difficult about it?

P04SS

I just felt I couldn't do it. I couldn't concentrate on doing both.

Interviewer

What was the movement exactly?

P04SS

Um, I can't remember now. Dear me.

Interviewer

It must have been something like walking or on the heels or?

P04SS

I cannot remember. No it was doing something like… well he had the music on. You know moving your feet. I don't know whether it was…

Interviewer

Like heel to toe?

P04SS

It might have been something like that. You move your arms at the same time. Well I couldn't because I was so busy focussing on getting my legs to do what I was telling them.

Interviewer

You were busy focusing on the feet.

P04SS

But I couldn’t concentrate on my arms as well. Is that coordination? I think it is.

Interviewer

Yep that’s coordination. Was anything offered to help overcome this problem?

P04SS

No he just said if you can’t do it just… not really he just said if you can’t move your arms just put them on your waist or hold onto the back of the chair.

Interviewer

So he gave you additional options in case you couldn’t do it with your arms as well?

P04SS

Yes.

Interviewer

Ok, because I think that everyone in the class are at different stages really aren’t they?

P04SS

Yea.

Interviewer

Right ok. So obviously you were very aware it was you doing the movements. So at any point was your focus on… ok so you’re thinking about doing the movement and you want to do it correct. Were you thinking about… she’s doing the movement like this and that?

P04SS

Not really. No. No.

Interviewer

Ok good. Fantastic. So there was no worry about your performance in the class at all?

P04SS

Oh no. No. If it’s rubbish, it’s rubbish (Laughs).

Interviewer

It is what it is. There’s always room to improve though isn’t there.

P04SS

I'm not bothered. Of course. I am more aware of other people being embarrassed and finding it hard.

Interviewer

And did you feel in control?

P04SS

I suppose I did to a degree. As much as I could do the things he was asking me to do. Sometimes I don't feel that I can control my feet and my legs properly. I don't know why.

Interviewer

But that's you focussing on the movement, you're focusing on the leg but you still don't feel it or..?

P04SS

Just sometimes it feels a bit like a dead leg you know.

Interviewer

Right. Ok. Ok.

P04SS

It just feels… well I must be able to use it or I wouldn't be able to… well the muscles wouldn't work.

Interviewer

I mean you've used both of them legs just there to try and get up from the floor

P04SS

Yes.

Interviewer

Like he said… he's reminding you that you're maybe still focussing on the problem with your leg and he's reminding you that your leg is doing its job at the same time.

P04SS

Yes. Maybe it's not the way it used to but it's…

Interviewer

But it's still there. It's still operational.

P04SS

Like the lady with a limp. Yes.

Interviewer

Yes so it's the same thing. It's not the same operational efficiency but it still can do a job.

P04SS

It’s learning your brain to think “I can’t do it the way I used to, but what’s the best way I can do it now?”.

Interviewer

So it’s almost like… that roads closed now so we are going to have to go down this side street.

P04SS

Go down another road. Yes. Yes.

Interviewer

And get to the same place

P04SS

Learn again how to do things.

Q.11. How do you feel the training program impacted your level of fatigue? How did this impact your motivation to train?

Interviewer

And it’s all about your attitude to doing that as well I suppose isn’t it? Ok so how do you think the training program has effected your levels of tiredness? Do you think that, from the start of the six sessions to now, do you feel that, obviously I know we have had Christmas break in between. Do you feel like you are becoming less fatigued? More fatigued now because you have been coming to these classes?

P04SS

Um… I think a little bit better. You know because it just gives you that little bit of a push to do something. I mean I’m pretty active anyway but um… it does give you a little bit of a boost. I mean I do feel… I’ve noticed that when I’m doing the exercises I’m always yawning so whether it’s lack of oxygen or what I don’t know.

Interviewer

After a class you find yourself yawning?

P04SS

I mean not tired physically just… um… I don’t know… just maybe mentally I don’t know.

Interviewer

Right ok. I mean I wouldn’t want to say what it is. I don’t know what it is but you find yourself yawning a bit at the end of a class?

P04SS

Yes.

Interviewer

Ok and did you find you were yawning more at the start of the program than you are now?

P04SS

About the same really.

Interviewer

About the same right ok but you don't mind the yawning because you know you have been worked or..?

P04SS

Oh no. No. I mean I've got a bit of a chest problem anyway and I'm trying to look into it to see if its asthma or something… what is it? COPD?

Interviewer

COPD

P04SS

Yea I've got something like that and I've been to see a neurologist as well. I've got to get a scan just to make sure there's nothing going on with us because I've only deteriorated this last year and I don't want to just… as I said before lay down and die. I want to try.

Interviewer

Yes it's good to get things checked out to see what's going on. Ok so do you think this fatigue that you are getting at the start and at the end of each session, it doesn't demotivate you to keep coming back?

P04SS

Oh no. No. Not at all no. I just want to do it you know?

Interviewer

Right ok

P04SS

The worrying thing is that everyone finds out what different classes they want to attend. If they want to go at all. That was going to be a whole new bunch of people that you are going to have to get to know again.

Interviewer

Yes there will be some preliminary anxieties with new folks but everyone's in the same boat.

P04SS

Oh yes. That's right. Of course. That's right yes. There's always somebody worse off than you.

Interviewer

Well exactly that's it. More than likely you might read somebody's body language and be like oh god, they're very sure of themselves or whatever but in their mind it could be the opposite so really you don't really know do you.

P04SS

Yea that's right. No you don't.

Q.12. Did the training program feel negative in any way in terms of your self-thoughts? (Negative self-talk) Did you feel absent during the program? Could you sleep ok? Slowness of thoughts? Angry?

Interviewer

So has the training program felt negative in anyway in terms of your self-thoughts? So negative self-thoughts or have you ever felt absent during a class?

P04SS

Oh no. No.

Interviewer

Has it had any effect on your sleep or?

P04SS

Oh I don't sleep good anyway. So no it's had a positive effect I would say rather than negative.

Interviewer

In what way?

P04SS

Um… well um it's just made me not give up and try and be better and motivate me. I think any form of exercise is good for just making you feel better and more energetic and… I mean I wish I had more energy but… no I think it's good. I like it and I enjoy it.

Q.13. Can you tell me how you feel when you go about everyday activities? Are there any fearful moments you have or concerns when you are out and about? (falling over)

Interviewer

Ok. Brilliant. So can you tell me, when you are going about your everyday activities, you said you are quite active… um so are there any… before you started the training program, did you have any fearful moments or concerns while you were out and about? So this is while you are out of the house or it could be when you are in the house. I know you mentioned the bath already but is there any other moments when you might have fear of falling over whilst you're out and about?

P04SS

Yea lots of times. I still have concerns but I'm trying to be sensible and see when there is snow on the ground I'm not going to go out because I'm going to be more at risk of falling. So I try to avoid that situation.

Interviewer

So it's almost like you're risk assessing first before you are going out?

P04SS

Yes and being more careful when… like I have had a few falls on buses.

Interviewer

You've had a few falls on buses did you say?

P04SS

Once off the bus and a few times on the bus but I try to show my bridge card and some of the drivers don't take any notice. I've nearly had a fall a couple of weeks ago.

Interviewer

Is that where they have pulled away before you have sat down?

P04SS

Pulled away yea when they have been too much in a hurry.

Interviewer

You can report that you know?

P04SS

I know but you don't like to cause problems.

Interviewer

It's causing you a problem though. I mean that's nothing for them to wait an extra five seconds until you have sat down. That's not a problem for them.

P04SS

I know. Some of them aren't very considerate. I mean some of them are lovely… um but I fell on the metro which was a bit unnerving.

Interviewer

On the actual metro itself or getting to the metro?

P04SS

On the metro because once again I couldn't get a seat and I went over the top of this woman's pram. I ended up on my back and hit the side of my hip of the wheel of the pram or the guard or whatever and that hurt a bit.

Interviewer

Ok. Has that instilled any fear at all while you are going out and about? Has it stopped you using the bus or the metro?

P04SS

Well it hasn't. I just try to hang on. Once again just risk assessment. Hang on for good life.

Interviewer

Good. Good strategy. Has this training program helped that feeling at all?

P04SS

Um… probably has yea.

Interviewer

Probably or what do you think?

P04SS

Yea I'd say it has yea.

Interviewer

Can you go into any detail as to how it might have helped?

P04SS

I think it's just the confidence the way he says you can do things just do it in a different way. Just be positive instead of negative and if you can't do things this way, try that way and you know, just trial and error really. So I'm just more careful… and what he said it certainly helped us to be more positive.

Q.14. How confident are you that you will not lose your balance or become unsteady in everyday outdoor and indoor activities now that you have received some balance training? E.g. Up and down stairs? Standing on a high surface? Escalator in shopping mall? Quick turning?

Interviewer

Right ok. Brilliant. Ok. So how confident are you that you will not… so from before you did the training to now that you are half way through? But obviously you have finished the six sessions you have done whilst I have been here, would you say you are more confident now when you are out and about? This could be outdoor activities, indoor activities, getting out of bed, in and out of the bath? So if you were to kind of scale each of these individual things that I have just said, would you say you are more confident now?

P04SS

I'm not confident in the bath. Definitely not no. I'm not confident there.

Interviewer

What is it about the bath? Apart from you have said it has happened a couple of times.

P04SS

We they have given me a bath seat and now I can't get… as I said it's my leg. There's something wrong with my leg and getting it over the side of the bath I found really difficult. I catch my feel a lot you know? So I don't think the confidence is about that. There's a problem there… I need to find out what that is.

Interviewer

But you are making steps. You have been to the neurologist, you have been to the doctors. You are going to find out about that. You are attending a balance class as well. Unfortunately they don't have bath tubs here to practice on a weekly basis but what he does show you is how to get to a chair. He shows you how to do that initial thing (movements of rising out of a shoulder dip) of that. That's why he says it's good to do the arm strengthening exercises.

P04SS

He did. He has explained about the bath and what to do and I've tried to put it into practice and it didn't work for me.

Interviewer

What would be wrong with getting in the bath, no water in it, getting in the bath, fully clothed and just practicing pushing yourself out?

P04SS

(laughs)

Yea I suppose.

Interviewer

And then you'd have… obviously what Richie's shown you there today about when you were lying on the floor and you go onto your side and you crawl towards something. If you can get onto your front in the bath and crawl towards the edge then you can help yourself to stand up like that, that's a method in itself.

P04SS

I know. I know. It's just getting over a little wall or a bath panel, getting over the side of the bath, getting over a little wall, climbing up and down steps. If I've got something to hang onto I'm ok. If I've got a rail but if there's no rail or anything to pull myself up or… um yea.

Interviewer

Like weary. So you say that you balance confidence has improved in some areas then and not in others.

P04SS

Oh yea it certainly has. I think it's strengthened some of the bones and the muscles in my body to a degree. I'm still having problems with this dead leg. Well I'm saying dead leg but it's just…

Interviewer

A lack of feeling?

P04SS

I would trip up on the tiny little… because there was a little crack in my back kitchen on the square tiles on and there's like little gaps in between and I keep, for some reason, keep catching my feet on the gaps or if there is a tiny little trim in between… you know your doorways, tiny little trip and I trip over that. I'm hopeless. I really am.

Interviewer

So it's almost like you need, because it that big (an inch) you kind of trip on it but if it was that big (6 inch) you maybe look at it and be like… right.

P04SS

That's right it's only a fraction of an inch honestly. So I don't know what that is and I need to get that investigated as I say.

Interviewer

Ok. So what about standing… getting on an escalator in a mall? Or standing up on a chair?

P04SS

I try to still go up on an escalator if I can because the man at the falls clinic says… he reckoned I had nerve damage in my feet. Um but the man I saw, the consultant I saw at the hospital didn't seem to think that the… because he was sticking pins in my feet.

Interviewer

And you could feel them?

P04SS

And I could feel them but not as much as I could on the other foot. He didn't stick many pins in but um… but he didn't think it was neurological? Is that the right word?

Interviewer

Yea so he doesn't think it's the signals coming from that side of the brain to the oppose leg but obviously it sounds like it needs a bit more investigating.

P04SS

Sorry I forgot the first question you asked there.

Interviewer

No the question was just… so in which areas do you feel more confident and in which areas do you feel confidence hasn't changed since you have been on this balance course?

P04SS

My confidence has changed. I'm still nervous about getting on and off buses but it's not as bad as it was. Getting on the metro I just hang on for dear life.

Interviewer

But it hasn't stopped you doing it though?

P04SS

No it hasn't stopped us doing it, no.

Interviewer

Right. That's good.

P04SS

And climbing up and down steps, I'm still nervous about that. I'm alright if there's something to hang onto as I said but it has helped but taken…

Interviewer

Hasn't taken away but decreased the nerves a little bit maybe?

P04SS

It's helped my confidence a bit… but it hasn't taken the problem away, you know what I mean. Obviously there's something wrong, with being this way the last year. So I think there's got to be something more to it you know?

Interviewer

Well if you feel there's something then you should get it checked out yea. Just it's a bit of a battle with the NHS as well.

P04SS

Nobody seems to be taking any notice. Oh it's a nightmare. It is.

Q.15. Is there anything else that this training has done for you that you would like to comment on?

Interviewer

So is there anything else that you would like to say about this training, what it's done for you, that you would like to comment on? Just making new friends or..?

P04SS

No not really. I mean I've got my own set of friends really. They are acquaintances but I wouldn't say… mostly my friends are Jehovah's Witnesses you see.

Interviewer

Oh right ok. I see.

P04SS

And it’s difficult sometimes, if you have friends that have the same goals, the same outlook on life. I mean totally different personalities but they all have the same look over the future.

Interviewer

Well it’s something you share isn’t it.

P04SS

And principles and…

Interviewer

So maybe if there was a balance training class just for Jehovah’s witnesses would you prefer that?

P04SS

Oh am sure (laughs) but I don’t think there will be because they are too busy focussing on what’s important. Giving people the hope for the future.

Interviewer

Ok. Alright. Brilliant well thank you very much for sitting down and talking to me.

Interview 3

Interviewer/Transcriber - Robin Tahmosybayat

Participant: P05SS

Location: Deckham Village Hall, Gateshead
Time: 37 minutes

Q.1.What are your thoughts on the training program? Did you enjoy it?

Interviewer

Ok so what were your thoughts on the balance training program so far? Have you been enjoying it?

P05SS

I did enjoy it.

Interviewer

Obviously it’s only half way through now-ish, about eight weeks to go I think.

P05SS

Yes. I found it interesting, you know, I enjoyed the program and learning things that you weren’t aware of, you know, like positioning yourself and when you are walking and going around instead of trying to step over. It’s interesting watching other people and how they reacted to it.

Interviewer

Sort of people, you know, in the same boat as yourself, they might be a bit weary of something.

P05SS

Yes looking at how they did things and thought that they’d done them properly and thinking to yourself I’ll… I’ll not do that (laughs).

Interviewer

Next time because, obviously yes, because that could have been you in that situation or something like that as well.

P05SS

Oh yes. Yes.

Q.2. Anything specific that stood out about the training program? (Favourite game? Favourite movement?)

Interviewer

I see what you mean yes. So was there anything specific that stood out about the program so far? Like something that you have been taught that has really stayed with you... It could have been the obstacle course? It could have been some of the hints and things that Richie would give you? Just for example.

P05SS

It was the obstacle course as well and… positioning yourself, you know, like holding your body and getting right back and how he taught us sit at the end of your seat, do the exercises with…

Interviewer

With the elastic bands

P05SS

Yes.

Q.3. How do you feel after a particular session during the training program?

Interviewer

Right and how did you feel would you say after a particular session in the training program?

P05SS

Energised. Looking forward to coming back really. I was enjoying it. I'd be telling lies if I said I didn't and I looked forward to coming but it was just that episode you know I do intend to get back.

Interviewer

That's fine. No as long as that's ok. So what do you think it was about the class that made you feel energised?

P05SS

I think doing the exercises.

Interviewer

And do you think you would have felt as energised if you were doing it one on one? As opposed to a group sort of class.

P05SS

I think the group helped.

Interviewer

In what way?

P05SS

I think being on your own, you wouldn't be sure whether what you were doing was right or wrong or being able to look at other people and seeing how they were trying like yourself and not quite getting it right and thinking oh that's how you do it, you know? Watching someone else and how Richie would say haven't you gone over it this time? (Obstacle course) And they would always think they had and he would say no you didn't. So I think it was good in the group.

Q.4. Any aches or pains that have gone away? Have come back?

Interviewer

Yes. Ok. Did you have any aches or pains at the start of the program that may have lessened or gone away entirely or not gone away at all?

P05SS

I did have aches and pains. They didn't really go away but they weren't as bad. They didn't feel as bad.

Interviewer

Like after a class?

P05SS

After a class. You did feel like you had loosened up.

Interviewer

Those bands are a bit stronger than what you think after quite a few repetitions.

P05SS

Yes they are yes and from how we first started he was quite relaxed about it but as the weeks went on he got quicker and he pushed you that little bit more. Because I haven't been I probably would see a change in how they're performing now.

Interviewer

Right. I mean last Monday all that he went through was showing you how to go down to the ground slowly and then stand back up so it was just standing in front of a chair, putting your hands on the chair, slowly stepping away and then going down onto one knee, then the other knee, and then bringing the hand down onto the ground from the chair, then going backwards on the ground and sitting in a position. Then he would get you to do the exact opposite. So when you have fallen and you are on the ground like this.

P05SS

That would have been interesting.

Interviewer

Well I mean he's going to do it next Monday, this Monday coming as well because there was only about six in the class last Monday.

P05SS

Was there?

Interviewer

Yea because everyone's got different things you know.

P05SS

I know. I thought I was still quite good because I didn't have any need to miss, I knew that hospital appointment was coming up because I sort of told him at the beginning. But I did find that it did help, help you, how you felt your body you know?

Interviewer

Yes. That's good.

P05SS

I did think that you know and so really I think I've got to try and get here.

Interviewer

Yea maybe's set yourself a reminder on a morning? Just be like this will make you feel better after, you know? Not necessarily the thoughts of oh I have got to go here, maybe in your mind on the day for some reason but you could set a reminder saying after this class I would have had social interaction with people, someone might make you smile and you might not expect it?

P05SS

Oh he did make you laugh.

Interviewer

He’s a funny guy isn’t he.

P05SS

Yes. He did.

Q.5. How does this compare to other types of training programs you have been a part of?

Interviewer

Ok. Have you done any other training programs like this before?

P05SS

No.

Interviewer

Ok and how did you become referred to this… did you refer yourself? Did you see a poster or..?

P05SS

The council referred me.

Interviewer

Was it the falls clinic?

P05SS

Yes. Um…

Interviewer

So I think the doctor refers you to the falls clinic.

P05SS

The doctor yes. I think she was a Victoria manson… referred me here and that’s how I came.

Interviewer

Right ok. So you’ve never done any type of training like this before?

P05SS

No I’ve never done anything.

Interviewer

And so obviously we are only half way through now so there is an opportunity to do eight more weeks of this training course. Richie has said it gets a bit more dynamic as the course goes on.

P05SS

Yes.

Interviewer

But he’s never going to push you beyond your limits which is partly what hes kind of said the whole way through really.

P05SS

Yes.

Q.7. Would you do it again?

Interviewer

But if you had the chance to do these first six weeks again would you come back?

P05SS

Oh yes I would come back.

Interviewer

Ok. Brilliant. So I’m going to ask you a few more questions now, a bit more in depth. Quite similar in nature to the questionnaires I gave you before at each of the measurement times, ok?

P05SS

Yep.

Q.8. What would you change about training program (Exergaming, Staying Steady) console, game) to make it more engaging?

Interviewer

Ok so I know you have said you have enjoyed the program and you liked seeing other people in the class, maybe what they, not necessarily do wrong, just you might have a similar thought process to doing a task as they did but Richie might have pointed out have you tried this instead? You know, so is there anything about the classes or about the training program, is there anything you would change to make it more engaging for yourself? To engage you in the balance. The balance is the focus, to engage you in balance, anything about it so the duration of the class, the amount of one on one you get within the group, I’m just throwing ideas out there but is there anything at all?

P05SS

Um… I wouldn’t know what to change Robin.

Interviewer

I mean so it's almost like um… to help maybe change your attitude to balance training, so not necessarily here but maybe to engage you at home for example? This is a ninety minutes that you come for here and the recommended training for people within your age group is about 150 minutes per week so there's still that hour per week that he gives you the home exercises for, you know the sheets of paper?

P05SS

Yes. Yes. Yes.

Interviewer

And at the beginning I think it was Nicola that gave you the booklets and she said I want you each week to do the different exercises that you do in the class. The people this week would have been trying to get up and down from the floor at home in a safe manner and do you think there's anything that could make you engage more of that at home in these classes?

P05SS

I think I would probably need, I don't know how I would manage that.

Interviewer

On your own?

P05SS

Here. I think it would probably take me a while. I'm not sure how I would

Interviewer

To get up and down from the floor. You'd be very surprised. You know Margaret, the lady with the short curly hair? She's got no mobility in her shoulder whatsoever. She was a little bit panicked actually. She was like "there's no way I can do this" and low and behold, she did it about four times. She was shocked in herself.

P05SS

Really?

Interviewer: She was like "I would never have thought I could do that" and Richie was like, that's because you're telling yourself you can't. Within reason don't push yourself, you know but everyone managed to do it. So I would like to put a bet on that I think you could do it.

P05SS

Really (laughs)

Q.9. What are your perceptions on safety of using this method (Exergaming/ Staying Steady) to train balance? (Self-efficacy) Were you anxious at all during training? (Anxiety)

Interviewer

Ok so nothing that you would really change to make the classes more engaging. Is there anything on the safety during the classes or this method of training balance, do you think it's safe enough?

P05SS

I think it's safe enough within reason because I've always tried to participate in what we've been asked to do. I'm not sure about the program that I've just missed.

Interviewer

Which program sorry?

P05SS

Last weeks.

Interviewer

Oh the last class sorry, yes go on.

P05SS

The getting up and down.

Interviewer

I mean like I said he's doing the exact same thing next week as well.

P05SS

I don't know how… I don't know if I'd be able to do that or if I would maybe be saying…I don't know. I don't know.

Interviewer

Ok so what is interesting is that maybe the thought of doing it could make you a little bit anxious maybe?

P05SS

Maybe. Maybe.

Interviewer

But you know it's something that everyone… everyone in that class last week was anxious about doing it but I can tell you now that everyone in that class was less anxious about doing it, which kind of tells you about the class and what it's there for.

P05SS

Well I think that's… you're right in saying that because part of the program that we've been doing, at first you know when we were having to go over the obstacles or walk in a straight line, I knew for a fact that I wouldn't walk directly straight. I knew I would go off and I think that if you do it, if you continue to practice it, it does get better.

Interviewer

Right. That's it. That's something that Richie, he kind of carries on saying throughout all his classes. I think he says "it's all well and good coming here and doing this but you need to practice it at home as well". So the importance of that home based exercise on your own, it's something that's the hardest often to motivate yourself to do.

P05SS

It's like you're moving and he'd sort of talk to you about how to think about how you are turning, what to do with your feet on occasions, even your body because that's my problem.

Interviewer

Right, your turning?

P05SS

Like, yes, movement and like going off, you know, or even going down. That's my fear.

Interviewer

Right. Ok. So you have these fears, whilst moving, of falling over. So the class is there to help train you to handle situations like this and so just to clarify, do you think the class is delivered in a safe manner to try to train yourself for situations like this? I mean I know you weren't there last week but if you are there this Monday you will get a better idea of how to get up and down from the floor but it's not just the actual movement that he's telling you about, it's the instruction and the way to think like you say, in that situation.

P05SS

Yes.

Interviewer

That's where I could see the anxiety levels in people lessening quite a bit and like I said, everyone managed to do it. So would you say that method is safe? He's not getting you to push each other over.

P05SS

Oh no. It's very safe the way he does it I think, you know. He's not putting pressure on you.

Interviewer

Ok. Right, that's brilliant. Or just mention a little bit about the anxiety. Would you say that you've come… from the first session to the last session you have been to, would you say that your anxiety levels have dropped? I mean bar external influence. Would you say your anxiousness about you balance and your ability to train your balance has kind of lessened as the sessions had gone on?

P05SS

Oh it's got better. It has got better.

Interviewer

Brilliant. That's almost like a motivator to kind of…

P05SS

Well it is yes. So anything that can lower your anxiety levels it's like well… if this is going to take something away, like negative like that then it's something that is motivational, it's like right I need to push myself there for these sort of reasons you know.

Interviewer

Ok so I'm just going to talk about flow now and sort of… when you are doing movements in the class. So he might just say everyone stand up and get behind your chairs, make sure you have got you chair at arm's length etc. going to do the balance part of the class now and he's going to instruct you on doing several different types of movements, whether it's walking on your heels, walking on your toes, stepping over obstacles, just rising onto your toes or anything like that, would you say that when you were doing that in the class you were conscious of the movement you were doing? Or was your attention elsewhere?

P05SS

No I was conscious of what I was doing. It was difficult that.

Q.10. Were you conscious of the movements being conducted during your training session? Where was your attention? Did you enjoy the experience? Worried about performance? Did you feel in control?

Interviewer

Any movement in particular that made you most conscious about?

P05SS

I think um… on your heels. That took a bit of concentration, yes, control yes.

Interviewer

I will tell you now. It makes me concentrate when I try and do it too (laughs)

P05SS

Oh dear (Laughs). Yes.

Interviewer

Ok so your attention was on the task itself?

P05SS

Yes it was.

Interviewer

So obviously you can't be one hundred percent concentrated in the class. There will be times that your concentration will be diverted at times.

P05SS

Yes.

Interviewer

It might be, like you say, looking at how someone else does something and that's almost like guidance on how you should or should not do it.

P05SS

Yes. It is.

Interviewer

So it's almost like having hints coming back to you within the class, is it?

P05SS

It is it's like, oh I can't remember, I think it's something like this…

Interviewer

With the band behind the chair maybe?

P05SS

No it wasn't the band behind the chair. I don't know what it was Robin or if it was one of these exercises (motions arms pushing forward and backwards alternatively). (Laughs) Someone opposite, I don't know if it was that lady that you have just been talking about, Margaret? With the very short hair?

Interviewer

Yes. She has quite short, light curly hair and her friend Liz has like the brown hair

P05SS

Oh no that's not the lady, I know who you mean. No it was another lady. She had actually joined after we did. I can remember looking at her and she sort of did something for to correct me, you know, (laughs).

Interviewer

Oh yes ok.

P05SS

I just laughed but I can't remember what it was and I thought "ey". She sort of did something, you know, to put you in the right (laughs)

Interviewer

Yes that's sort of assistance isn't it (laughs)

P05SS

But um… oh I enjoyed it. I mean, you know?

Interviewer

Yes you have enjoyed the experience of kind of learning, not just from Richie and what he is doing but getting companionship and learning like getting silent hints from other people in the class as such.

P05SS

Yes. Exactly.

Interviewer

Right. Brilliant. So I mean at any point during any of the classes, it could be on any task, it could be at the beginning of the class, were you worried about your performance like in comparison to like what Richie might think? In comparison to what other people might think? In comparison to what you didn't know about yourself already maybe?

P05SS

Um… I was conscious when I first came. Like getting your coordination right. I don't think I was worried about what other people thought. I just thought oh we are all in it together you know?

Interviewer

Yes. I think that's how everyone kind of perceives it you know?

P05SS

Yes.

Interviewer

Ok. Brilliant yes. So like you said the walking on your heels, walking over the obstacles but then Richie would make you do it backwards. This is where everyone's gone "you what? I can't do that", you know, he says "well". By the end of it he had you side stepping which changed the way. So that's an example of how he changed the way you thought.

P05SS

Yes.

Interviewer

It was just interesting. So a lot of people kind of did it forwards

P05SS

They did yes. Then they realised. Yes.

Interviewer

Then as soon as he said do it backwards, what happened?

P05SS

What happened? (laughs)

Interviewer

Everyone just went (froze) “I can’t do that”, you know, and I don’t know if you were at this one?

P05SS

No I didn’t do that one.

Interviewer

Ok. I was thinking otherwise you would have given me a hint at what you felt like at that moment in the class. But in another class for example, when you’re on your tip toes or when you’re on the heels or when you are doing the side leg raises, did you feel in control of the movement? As in you weren’t just, you know, swinging out or..?

P05SS

No I felt when we were doing those side leg exercises, I did feel that I was in control but maybe I could have been… I probably needed a few more goes at that to feel that I was getting it right.

Interviewer

Ok. Ok. So a bit more time on that task? Would you say?

P05SS

Yes. Yes.

Interviewer

Right. Ok. I guess that must just be a time constraint of trying to get as much done in the class as possible. There’s also the fact that he’s got to see many different people in the class as well.

P05SS

That’s it. Yes.

Q.11. How do you feel the training program impacted your level of fatigue? How did this impact your motivation to train?

Interviewer

Ok so we’re just going to talk a little bit about fatigue now. How did you feel that the training program impacted your level of fatigue? So if you could first tell me about near the start of the program? At the beginning and end of an individual session? So if we just say as the program as a whole so far?

P05SS

Um… I think as the program went on, I felt more energised and I knew that I had put my body under something that it hadn’t actually been under for some time. So I did feel like er…

Interviewer

Like how did you feel the next day? Did you feel in your muscles a bit more stiff or..?

P05SS

The next day I felt ok. I wasn't stiff. I actually felt like it loosened you up a little bit you know?

Interviewer

Right.

P05SS

I wasn't in any discomfort, um, through doing that, you know?

Interviewer

Yea ok and how did that, did that motivate you to come back to the classes more do you think?

P05SS

Oh yes.

Interviewer

It's like once you get that feeling it's almost like ok. It's also once a week so by the time it comes back to the end of that week, I don't know if this is applied to you or not? You feel like you want that feeling again you know? It wears off as the week goes on.

P05SS

Yes. It does and you are ready to come back again and do it you know? It was just unfortunate.

Interviewer

Of course. Yes I understand that.

P05SS

If it had been any other time, I probably would have carried on.

Interviewer

Well it's still not too late to carry on you know? You've still got that chance to come back and experience that group. That social interaction, that interconnectedness with people which could be very beneficial for you right now you know?

P05SS

Yes.

Interviewer

Obviously pending your anxiety levels.

P05SS

Yes.

Q.12. Did the training program feel negative in any way in terms of your self-thoughts? (Negative self-talk) Did you feel absent during the program? Could you sleep ok? Slowness of thoughts? Angry?

Interviewer

But um…this next topic is just… it's like the questionnaire we did on depression. So it's asking you things about how you feel in your life and I know there are obviously external things again that have impacted how you feel right now so if we could try and zone in on the program itself, try to ignore those other factors, just for the sake of this interview, obviously there's going to be some impact in you coming or not coming to the classes I understand that. Did the training program or the classes make you feel negative I anyway in terms of your self thought? So not the other areas in your life, but coming to the class.

P05SS

No. No.

Interviewer

Was it purely a positive experience?

P05SS

It was.

Interviewer

Well that's good to know. That is fantastic to know. Obviously they don't want people coming and having a bad time, you know?

P05SS

Oh no. No I enjoy it.

Interviewer

Ok and even though you're enjoying it, is there ever a time in the class where you felt like a little bit absent? Like you would have done with a bit more mentoring of anything like that? Anything that made you feel sad?

P05SS

No I didn't feel anything like that.

Interviewer

Brilliant. That's grand. Has it impacted your sleep levels at all? I mean it's difficult to know if it's this impacting your sleep patterns.

P05SS

No I don't think so. No.

Interviewer

Right ok. That's good to know. So it's all positive then?

P05SS

It’s all positive.

Interviewer

Even more reason to come back and get involved then isn’t it.

P05SS

it is. Yes.

Q.13. Can you tell me how you feel when you go about everyday activities? Are there any fearful moments you have or concerns when you are out and about? (falling over)

Interviewer

Brilliant. So when you’re going about your daily activities now, no matter what you do, you know, you’re getting the shopping in, you’re going to see a friend or whatever it is you’re doing, pottering around the house, you know, whatever you normally do. Are there any fearful moments you have now or concerns of falling over? In the house first maybe?

P05SS

No. I’ve got no concerns about falling over, I don’t think. It’s not on my mind that I’m going to fall.

Interviewer

I know that over the winter break we’ve had a lot of ice on the pavements.

P05SS

Oh I just avoided it.

Interviewer

Did it stop you going outside?

P05SS

No. No it didn’t. I was just careful. I was careful. I think more aware through coming here of how you are moving your body, you know?

Interviewer

And maybe how you can tackle those situations?

P05SS

Yes.

Interviewer

Ok. So like I know when Richie’s obviously talked about… Well I’ve noticed that he’s mentioned in the classes that if it’s icy outside he’s kind of telling you to make sure there’s something to grab onto, you know…

P05SS

Yes.

Interviewer

So don't go somewhere down a hill where it's got a sheet of ice.

P05SS

Yes.

Interviewer

He's just kind of making you more aware of your environment really isn't he?

P05SS

Yes. That's right.

Interviewer

So you hadn't really had a fear of falling over at the start of the program at all?

P05SS

No. Never. Just um…

Interviewer

Ok brilliant. So you did mention that you obviously been referred because of issues with falling with medication but that's never instilled a fear in you which is great.

P05SS

No it hasn't .

Interviewer

That's fantastic.

P05SS

I mean I do at times think about it but I don't dwell on it and touch wood I'll not… I think if anything, the programs given me a lot of insight as to how you use your body and move and made you aware of dangers that could be there.

Q.14. How confident are you that you will not lose your balance or become unsteady in everyday outdoor and indoor activities now that you have received some balance training? E.g. Up and down stairs? Standing on a high surface? Escalator in shopping mall? Quick turning?

Interviewer

Ok. Right yes. Fantastic. Brilliant. I think that's the text book answer they want to hear in there (laughs). Ok so this is very similar to the fear of falling over questions but it's more focused on your confidence with balance personally. Similar to the questionnaire, the activities that you do in the day, how confident are you that you will not lose your balance doing them? Whether it's standing on a chair in the house? I don't know if you did that before the training program. Is there anything that you wouldn't have done because of your lack of confidence in your balance that you are now doing after the training program? ….Like up and down stairs, getting on an escalator at the metro or I know you mentioned turning was an issue with you, have you seen an improvement in your confidence with doing these things?

P05SS

I think I have seen an improvement in my movement because through coming here its taught me how to move, how to turn…

Interviewer

How not to turn as well.

P05SS

Yes.

Interviewer

Ok and any particular movements that might spring to mind that you feel more confident doing apart from maybes turning?

P05SS

Um… any more movements…

Interviewer

It might not necessarily be movements… it might be how Richie tells you to sit at the edge of a chair before standing, maybe the things that you found difficult in the class? Have they decrease in difficulty when you are doing them outside of the class?

P05SS

No they haven't. I mean when you're doing like um…everyday things that… I have stood on a chair which I wouldn't have done before I came here, and managed it ok

Interviewer

Well I mean that's physical evidence really isn't it that you are being more confident in a way.

P05SS

Yes and I have stood on the ladder to move the light outside (laughs).

Interviewer

Right ok and you wouldn't have done that before either?

P05SS

I wouldn't have done that before.

Interviewer

Well, there you go, there you go.

P05SS

I wouldn't have done that before. Because the light had gone off, the bulb needed changed.

Interviewer

So were you doing that in the dark or was it daytime?

P05SS

It was daytime but when it got dark, the light hadn't been in the position it had been so it wasn't generating enough light far enough down the garden so I had to position it a little bit.

Interviewer

Right ok. So you were back up on the ladder again were you?

P05SS

So I wasn't right up on the ladder you know but I needed to go on the ladder to manoeuvre it.

Interviewer

Did you have any feelings whilst you were doing that?

P05SS

No I was just conscious of being careful. You know?

Interviewer

Brilliant. Yep.

P05SS

I'm very determined. Coming here has helped me to feel confident in doing the things because I wouldn't have done that. No I wouldn't have done that.

Interviewer

I was going to say, must be more confident.

P05SS

Because I have never let anything beat me but I know the last couple of years from going down did sort of make me put my guard up and think no you're not doing that.

Interviewer

Ok yep so that guard that has come up in the last couple of years and then this program, has it maybe helped lower the guard a bit?

P05SS

I think so yes.

Q.15. Is there anything else that this training has done for you that you would like to comment on?

Interviewer

Well that's good. I think that's what it's here for, which is fantastic. All the more reason to come back (laughs). So is there anything else that this training or coming to the classes has done for you that you'd like to talk about today?

P05SS

Um… It's just um… giving you another interest you know, knowing that you have been coming, you know, preparing yourself. I can't say anything else other than I've enjoyed it. Was a little bit apprehensive after Nicola said she was leaving, you know,

Interviewer

Yes I got a shock too when she said she was leaving.

P05SS

Because you sort of got a bit of a bond with her before the program had started. I sort of knew her on… because I'd spoken to her a lot. She'd contacted us a lot by letter because I waited a while before this program had started.

Interviewer

Were you on the waiting list?

P05SS

I was.

Interviewer

Yes. Right.

P05SS

So she was sort of keeping in touch with you and that you know?

Interviewer

And you do. You develop rapport with her don't you?

P05SS

And when I met her just a couple of times in here and she said I'm leaving but it's been ok.

Interviewer

I mean you get to know Richie very quickly don't you?

P05SS

Oh you do yes.

Interviewer

He’s not really… he’s not one of these holding back personalities.

P05SS

No he’s sociable, he likeable yes.

Interviewer

Yes exactly, and that’s important in this work as well.

P05SS

Yes it is.

Interviewer

Ok brilliant. Well I think that’s the end of the interview.

P05SS

Is that it?

Interviewer

Yes.

P05SS

Thank goodness.

Interviewer

Thank you very much.

Interview 4

Interviewer/Transcriber - Robin Tahmosybayat

Participant: P06SS

Location: Deckham Village Hall, Gateshead
Time: 30 minutes

Q.1.What are your thoughts on the training program? Did you enjoy it?

Interviewer

What were your thoughts on the training program? Have you been enjoying it?

P06SS

Oh I always enjoy exercise.

Interviewer

Ok, specifically about this program, have you enjoyed coming to the classes? And what you have been doing in the classes?

P06SS

Just the exercises and they are good. I do them every day but I find a rather do them before my walk because when I've done that power walk I'm knackered. So I've got it, I do it first thing then I go onto the walk but I still can't do the foot in front of the other balance thing.

Interviewer

Like that (tandem stance).

P06SS

I can't do it.

Interviewer

Yes so some things are going to be challenging obviously. You can't do everything straight away either you know.

P06SS

I have tried.

Interviewer

It's good that you are doing the home exercises. So obviously some people will come to the classes and they will go away and they'll not do the exercises. They might do it at the start but

P06SS

Oh I do it every morning.

Interviewer

Right?

P06SS

I don't do the walking bit because I've done it. It comes after and believe you me, the bit of walking you do here is about one hundredth of what I do when I go out. I go right round the outside of the park.

Interviewer

Right ok. Ah yes you have told me before, Saltwell Park is it?

P06SS

Yep. It’s a forty minute power walk.

Interviewer

That’s awesome.

P06SS

Might be thirty for you.

Interviewer

Well not after Christmas mate (laughs)

P06SS

(laughs)

Q.2. Anything specific that stood out about the training program? (Favourite game? Favourite movement?)

Interviewer

So is there anything specific about the training in the classes that stood out for you? So what you have really benefitted from?

P06SS

Yes I find that using the… my limbs are better and stronger. I’m still struggling to get up but it’s not as bad. You know what I mean?

Interviewer

Right ok. Yep.

P06SS

One of the things is trying to get up without any help. I still I have to help myself, I’m eighty-four man.

Interviewer

No no I get that, I understand that completely. The things that he’s kind of teaching you in the classes like maybe if you were sat back in your chair and you tried to stand up. Now Richie kind of tells you in the class, sit forward at the edge of your seat, then you come forward so you are looking over your toes and then you stand up and its these sort of educational things as well, isn’t it?

P06SS

Yes exactly. That’s become natural now, you know

Interviewer

Brilliant yes.

P06SS

Every time I come back in you know

Interviewer

Is that because you're doing the home exercises as well do you think?

P06SS

Oh I think so, well I hope so.

Q.3. How do you feel after a particular session during the training program?

Interviewer

Ah it sounds like it could be. So tell me how you feel after a particular session? After you have been here for the class?

P06SS

At the class?

Interviewer

Yep.

P06SS

Good I feel loose.

Interviewer

Yea? Like a similar sort of feeling when you have been out doing you're walk?

P06SS

Well this is it. Everyday I'm fit. I mean you know I've never sort of… I'm just rocky that's all. When I first came to a physio man, you know, very clever, and he used the prod.

Interviewer

Ok.

P06SS

And he says um… I thought it was a needle, it looked like it. He says "I'm afraid you're numb". I thought thank you very much (laughs) not from the neck up (laughs) from the ankle down he says.

Interviewer

Right (laughs)

P06SS

So what he was doing was very clever. He said that's why you're tripping Mr. Anderton. You're misjudging it and then when I'm on the walks here and I'm to step over…

Interviewer

You can't feel it?

P06SS

I can do it but I have to do it in a crazy manner to do it.

Interviewer

Yea? Like the feelings not there?

P06SS

I can't feel… I don't know if you'll understand. I can't feel how far my foot has come off the ground now. I dance… I dance, you know, and I golf.

Interviewer

You're quite an active person then for an eighty-four year old man you're very active aren't you.

P06SS

I'm very active, I'm very active. That's why this is starting to kick me now but listen Robin, when I fall down on the floor there, don't resuscitate me. I've done the living will. I've had a good life. I've done eighty-four years and, you know, I've made every bloody minute count, especially after the divorce. When you've had a difficult life… when it shakes off, you think right… I'm going to live for me now.

Interviewer

Yes I get that.

P06SS

But I didn't. I met somebody and blah blah blah (laughs).

Interviewer

Yes but you've had some time for you though, haven't you?

P06SS

I've had a good life from… what, fifty. So I've had thirty-four happy years.

Interviewer

Thirty-four years. Well good. Brilliant. So you've just talked briefly then about having the numbness in your feet. Has coming to the classes… has it helped you cope with that a bit better do you think?

P06SS

I can't say really. I just do them because they're exercise and I'll do anything that benefits me, you know?

Interviewer

Yea that’s a good attitude towards it.

P06SS

I do think I’m keeping up better than I might, because I’m doing the elastics and …

Interviewer

The elastic bands?

P06SS

And I don’t need the legs really because I walk, you know.

Interviewer

Yea. But the upper body stuff, the elastics good for.

P06SS

The upper body. I’ve never been strong mate. I mean I was from a very big family and I grew up like a rake. Very underfed, under clothed in my day, you know?

Interviewer

Yep.

P06SS

Poverty was rife. So I never made, I mean I would have made… I mean I’ve got some older brothers that obviously weren’t hit as bad as me because I was like number eight and they had a few years before the other kids came along and they’d built a bit of body. But I was like… me and my brother, we were like two rakes

Interviewer

Couldn’t build it?

P06SS

You know and it’s only since I started to get this body weight on me with old age. I was just a rake man. I was a thirty-two waist all my life. Ten and a half stone and I’m six foot.

Interviewer

I don’t think I’ve been a thirty-two waist since I was about twelve honestly (laughs). Right ok.

P06SS

Right so I’m not a strong person on the top

Interviewer

But you’re very active you know, you’re very active.

P06SS

Yea. I have a bad spine but that was an industrial accident. I'm under a chiropractor permanently.

Interviewer

I remember you telling me yes.

P06SS

Every six months I have to visit him.

Interviewer

Right ok. So how does this type of training that you have been doing in these classes, you know, so whether it's trying to step over the obstacles, trying to stand on a chair.

P06SS

I don't know. I can't honestly say. I'm more aware now of this problem with my feet so that's definitely made a difference, you know. But had I not been aware ten I could have given you more accurate. It's all combined things I'm doing, all which has come from this falls clinic, which you know is…

Q.5. How does this compare to other types of training programs you have been a part of?

Interviewer

Right ok. Did you do any training with the falls clinic before you came here? Did you have to go to any classes at the falls clinic before you came to the staying steady classes?

P06SS

Well this is it isn't it.

Interviewer

This is what they referred you to?

P06SS

Yea.

Interviewer

Ok, just I've had other people who have done classes with the falls clinic and then they have come here as well. I just wanted to see if you had done a similar thing or not?

P06SS

No. I'd been on um… about three months before I started I went on a heart… what's the word… bringing it back.

Interviewer

Resus… no not resuscitation no. No. Like rehabilitation?

P06SS

Exercise to get the heart going.

Interviewer

The heart going. Like aerobic exercises and stuff like that.

P06SS

What was it called…? Heart reh…

Interviewer

Heart rehab… anyway.

P06SS

Do you know man it's a good job you phoned me. Now I've known ever since you said that I'm coming here. This morning, and it happens you know, I miss appointments.

Interviewer

Well because you get into your daily routine that you are normally used to doing isn't it.

P06SS

Oh I'm very routine mind.

Interviewer

Well I imagine that you don't have appointments every day do you?

P06SS

No.

Interviewer

Exactly so it's…

P06SS

But if I've got an appointment I've got to put it on the wall, put it on my calendar.

Interviewer

Yea. Yea. I mean loads of people do that. Everyone does that. Maybe you wouldn't have used to do it.

P06SS

It's age. I used to be sharp as a tap

Interviewer

Well that's it then must be just kicking in a bit.

P06SS

Maybe I’ve got Alzheimer’s (laughs)

Interviewer

I don’t think you have that. No way. I can tell that. I can tell. So tell me which movement or which class you’ve most benefitted from so far?

P06SS

This one I’ve been doing.

Interviewer

Which one? I mean which class within this… I mean you’ve been to about six, seven or eight classes now here. So is there a particular class or do you think they are all as beneficial as each other? Any individual class?

P06SS

Because I’m fit I think they’re just as beneficial. I’m not saying… I definitely feel, I feel that my upper body is stronger.

Interviewer

Right ok.

P06SS

But otherwise I’m very strong anyway.

Interviewer

But if we are really trying to focus in on your balance

P06SS

I mean some of these poor buggars here coming to this exercise, they’re ancient and they’re not as old as me.

Interviewer

I mean there’s a difference. Your physical activity levels…

P06SS

They’ve done it themselves man. They’ve done it themselves because they are sat like this. A bloody cabbage potato. What is it? Couch potato? (laughs) All their lives and then they… they’re expected to do this.

Interviewer

It’s difficult but for someone who’s obviously been active such as yourself throughout their life. They might see the benefits quicker.

P06SS

As well as. No. No it's as well as because I golf and when I golf I'm doing my exercises with golf and, you know, get yourself loose. You know, you don't just go on a course, you loosen yourself don't you.

Interviewer

Of course yea.

P06SS

So yes… it has definitely helped to some extent that's all I can say but had I been a couch potato as I say it probably would have helped a lot.

Interviewer

But because you are already active.

P06SS

I'm fully active anyway. About two years ago I did that living will and I mean I'm on my own up here. I've got two grandchildren. My daughter would have me but she's got her husband's that's MS. He's just a cabbage sitting in a chair, you know, even his head has to be… she has to feed him and everything so… I'm eighty odd and I don't want to lumber her mate you see what I mean?

Interviewer

Of course. I understand that.

P06SS

So I'm on my own. If dropped here now I don't know whether my solicitor would find out. Do I have to carry that with me all the time? I've got about seven of them.

Interviewer

I'm not sure what that is.

P06SS

Does the ambulance man look in your pockets when you've had a heart attack?

Interviewer

Honestly, I couldn't tell you.

P06SS

They would try and resuscitate me and I'll tell you what, I should be really sorry because I don't want to be a… I mean I know I've looked after lots of people but I don't want to be a encumbrance.

Interviewer

You see I understand that. That's your own personal choice.

P06SS

You know what I mean? I know what it's like. I know what it's like to have to tend to somebody and I'd rather be gone.

Interviewer

I get that. Ok. I respect that. I do but what I want to do…

P06SS

I'm fit as I can be and also I use this (angina spray)

Interviewer

Yes I can tell, I mean you are and you push yourself every day. Good. Good. So what I want to do is I want to really focus on the training classes because what I'm doing is I'm comparing these classes with another group of people who have been coming to the university. You see, they have been doing a different method to train their balance so that's why I really want to focus on your experience purely in these classes and how it has benefitted you from what you can recall, ok?

P06SS

Top half definitely, bottom half I can't give you a judgement because I've just walked right down from the park, it's nearly killed me coming up here. I've had to have my puff. When I got to the top I was knackered (laughs). It's a hell of a climb you know from down there.

Interviewer

I know. I usually drive up it. I don't usually walk up it.

P06SS

You walk it. You'll be gasping at the top. It's like that (motions his arm to look like a gradient). It's a beautiful view though.

Interviewer

Oh I know. It is worth it when you get to the top isn't it.

P06SS

I get that view when I'm golfing you know. Do you know where our clubhouse is? Long bank. I look down on the angel.

Interviewer

Right. Oh right ok. Yea I know where the angel is just off that roundabout isn't it.

P06SS

Very big. Keeps you fit man (laughs)

Interviewer

I know. Sounds like you're doing more than me Cyril (laughs).

P06SS

I'm not surprised (laughs)

Q.8. What would you change about training program (Exergaming, Staying Steady) console, game) to make it more engaging?

Interviewer

So I want to zone in now on the sessions ok? Now I just want to know what you would change about the classes to make it a bit more engaging for yourself.

P06SS

Well I thought it was very comprehensive because I still struggle now to remember all of the exercises that I have been given and I think well… I can't think of… I've done this, I've done that yes, you know what I mean? It's never come as routine, I just do it because it's trying to help you to help me you know what I mean?

Interviewer

Yea exactly.

P06SS

It's no good being, you know you've got to do your best.

Q.9. What are your perceptions on safety of using this method (Exergaming/ Staying Steady) to train balance? (Self-efficacy) Were you anxious at all during training? (Anxiety)

Interviewer

I think that's the best attitude to have towards it as well to be honest. Ok and what about safety? Do you think the classes were safely led? Do you think the classes were safe for you to attend?

P06SS

Yes. Very clever. Very clever. Well thought out isn't it.

Interviewer

Ok. Good. So using these classes to train your balance. He (Richie) puts you in situations in the hall maybe that you might experience when you're out and about, you know, like stepping over the obstacles, walking backwards…

P06SS

Oh it's made me more aware yes. You know, to do different things to compensate for that lack of what I've lost.

Interviewer

Right yes exactly. I think that's exactly what he wants to do.

P06SS

It’s from there (points to his head) as well as… I mean that’s what he’s drummed into us and I mean if we don’t do it then it’s our own fault isn’t it?

Interviewer

Yep. Exactly.

P06SS

He can only give you the information. Making you realise you can’t do that. It’s up to the individual.

Interviewer

Yep and everyone’s different aren’t they.

P06SS

It’s just that I’m receptive that way you know?

Q.9. What are your perceptions on safety of using this method (Exergaming/ Staying Steady) to train balance? (Self-efficacy) Were you anxious at all during training? (Anxiety)

Interviewer

Yep and what about anxiety? Did you feel any anxiety when you first came to the classes?

P06SS

No.

Interviewer

Nothing at all?

P06SS

No, because it involves exercise and I’m a physical man you know?

Interviewer

Good so you are quite confident in that aspect and in front of other people, because it’s a group class so any anxieties with other people at all or..?

P06SS

No because I’m not… I mean I know you think I’m not because of the way I go on… but basically I’m a bit shy you know. I can’t help it.

Interviewer

Well it doesn’t come across with you, I’ll be honest, it doesn’t at all.

P06SS

Well that's because I've learnt, it's learning curve, when I became a copper, you've got to mix, then I became a gaffer later in my life. I've had men under me and you've got to put it over. So it's altered me completely.

Interviewer

I see so for your job you had to make that change.

P06SS

Basically, when I was a child, we was always in a group and I was always at the back. They say "come one Cyril". I'd say "I'm alright" (laughs). They'd be doing this and I'd be doing this.

Interviewer

So your past work life has helped you in situations like this now then?

P06SS

Oh yes. Yes. All of it because since I have been like divorced I've come right out.

Q.10. Were you conscious of the movements being conducted during your training session? Where was your attention? Did you enjoy the experience? Worried about performance? Did you feel in control?

Interviewer

Brilliant. Ok so I'm going to ask you about being conscious of the movements you're doing now. So during one of the classes or any of the classes, did you feel like your attention was on the movement you were doing or was your mind elsewhere whilst you were doing the movements?

P06SS

Well... my attention was on the movements.

Interviewer

Ok… as that's where Richie wanted you to focus really wasn't it.

P06SS

Oh yea. Yea. Well it's no good if you don't.

Interviewer

Yep. I know. Well this is it, obviously.

P06SS

Do it today. Bugger it after that. No you've got to do it (laughs). Keep it going.

Interviewer

Ok and how about when you are at home doing the home exercises? Are you aware that you are focusing on them as well?

P06SS

Oh of course yes.

Interviewer

Ok and what about the experience in the class? You enjoy it? You enjoy the experience?

P06SS

I always have the initial thing… I'm… I'm fine really. I mean I… everything… lots of things I do, I hesitate but I do it. It's no good not. You can't sit in the house can you?

Interviewer

No. No, you are absolutely right. I think it's a very good attitude to have towards it.

P06SS

I must confess… I have to push myself a bit socially but physically I'm very capable.

Interviewer

Right. Brilliant. So were you worried about your performance in the class at all?

P06SS

No. I'm more worried about others than me. You know what I mean? Because they think I'm a bloody show off. It's when I dance. You know, I'm very precise when I dance… and I think… well I had a brother you know, second oldest. I'm one of six boys, and I used to watch our Tommy, he was a bloody show off, but I'm made like Tommy it was eighty-nine when he popped his clogs but everything he did had to be right, you know what I mean? (laughs)

Interviewer

I know. I t's perfectionism in a way isn't it?

P06SS

Like Tommy I am. They think you're showing off but you're not. If there's a movement to be done, you do it because its perfection isn't it? The same as this (balance training).

Interviewer

Yes. Absolutely and you repeat it as well don't you?

P06SS

You've got to.

Interviewer

Yep. Ok.

P06SS

You musn't get bored. Making the effort stops you getting bored.

Interviewer

But the more you do it as well, the more do you feel in control?

P06SS

Oh yes. Oh yes. I definitely benefitted from it.

Q.11. How do you feel the training program impacted your level of fatigue? How did this impact your motivation to train?

Interviewer

Right ok so I'm moving on now to fatigue. So how do you think from before the classes to now, the classes have impacted your level of fatigue? Do you think much has changed? Do you think you have become fitter? Do you think you have become more tired?

P06SS

Eighteen months, two years ago, it would not have affected me and when I'm doing them it doesn't but I'm still finding that when I'm under extreme physical stress, which I can't help it, it's just the way I am, I start.

Interviewer

You start getting the feeling…

P06SS

Now all my life from when it come on since I was about fifty. I was perfectly hard physically but you stress me and it pfft.

Interviewer

Right. You can feel it straight away?

P06SS

If you had a go at me, you know, snapped and stuff, I'd straight away, pfft. I mean I wouldn't stand for it.

Interviewer

No. Obviously not.

P06SS

I've just left my last partner through it. I was with her about five years and I said listen "this last twelve months", I said "stop that Hazel" I said "because we're only friends and you're going to lose a friend because it's affecting me". "What do you mean?" I said "I've always had angina", "oh have you?", "I said yes I've had it for thirty odd years and I've got away with it but you've brought it on", "oh I'm sorry" blah blah blah but she did it again and again and I said "Hazel, goodbye".

Interviewer

Can’t be doing with the negativity

P06SS

No. No. No I can’t man I’ve had enough stress with me.

Interviewer

Well I can understand that

P06SS

That’s why I think it comes on with stress. I’ve got to the end of that patience.

Interviewer

So I’m bringing it back into focus on the classes alright?

P06SS

Oh sorry yes alright sorry.

Interviewer

No no it’s alright. Im going to keep on bringing it back in just because I need to keep focussed on the classes.

P06SS

Of course.

Interviewer

So the classes that you have been coming to, would you say that it has or it hasn’t effected it then? Would you say a little bit? Have you felt a bit more tired?

P06SS

Upper body.

Interviewer

So like upper body you have felt a bit more fatigued?

P06SS

Stronger yea. No. No. No. Stronger.

Interviewer

Your general fatigue levels? Do you think they have changed?

P06SS

General fatigue has gone up as regards to the top (stronger). I can’t say the bottom because I’ve always pushed it.

Interviewer

Because you're always keeping active. So there's no difference in the bottom but you've noticed maybe's a bit more tired after doing the arm exercises during the week? Maybe or?

P06SS

Initially.

Interviewer

It's alright I mean…

P06SS

I mean going from the outset. I'm now using the pink elastic, not the blue, because I can do the exercises more efficiently. With the blue one it… oh… it was hard. I'm not a strong bloke really.

Interviewer

That's alright though. That's fine.

P06SS

I know it sounds crazy but I'm not. I'm fit but I'm not physically strong. I never have been.

Interviewer

I mean we're all different in different regards, you know. I mean I can lift heavy but I can't run a marathon, you know, so we're all different in different ways. How do you think this fatigue, do you think it motivates you to come to the classes more? Like "Oh I can feel my arms, I want to go back and do that again" ... or?

P06SS

I don't allow that to happen because I keep doing it.

Q.12. Did the training program feel negative in any way in terms of your self-thoughts? (Negative self-talk) Did you feel absent during the program? Could you sleep ok? Slowness of thoughts? Angry?

Interviewer

Brilliant. Ok. Now I'm just going to talk about some questions on depression, alright. So it's just relating to the classes. Have you had any negative thoughts during the classes? At home? I don't know if you have negative self-talk in general though. It doesn't sound like you do. You sound like a very positive person. So I just want to see if the training… has it made you feel negative in any way coming to the classes?

P06SS

No. Except that it's taken a couple of hours out of my day (laughs) but it's worth it.

Interviewer

Right ok yea. I mean that's almost like… exactly… exactly. It's just part of…

P06SS

It's a good deal isn't it.

Interviewer

Has it influenced your sleep patterns at all?

P06SS

Well… no, just the same. I can sleep immediately but if I wake up… I've got a lady pestering me at the moment, I must give you why. I'm not sleeping well lately because of this woman and I've got to tell her, no. You know, I don't like that approach but I've said to her a couple of days ago. I said "Listen. I've got to come up to your place and we've got to have a serious talk" Because I've got to tell her that I can give her twenty years because I'm not as young as she thinks I am and I'm no bloody good physically, so, you know what I mean? And because of that… I've lost my sleep because I don't want to hurt people.

Interviewer

It sounds like it's something that you might need to say but you don't really want to say

P06SS

No, but I've got to do it.

Interviewer

Yea well you will probably sleep better once you have done it.

P06SS

Oh yea. I know I will.

Q.13. Can you tell me how you feel when you go about everyday activities? Are there any fearful moments you have or concerns when you are out and about? (falling over)

Interviewer

Ok so when you're out and about doing your walks, do you think coming to these classes has helped you become less fearful of falling over when you're out and about?

P06SS

Yes.

Interviewer

Yes? So obviously being aware of the numbness in your feet.

P06SS

No. I never have been mate. It's just feel. It's not numbness. I don't go numb. It's just feel. That's why I misjudge. Until he told me… I mean that alone was like, invaluable to be told wasn't it? I was quite unaware of it.

Interviewer

Absolutely. Well if you are unaware and then you're made aware then that's good.

P06SS

When I came here I was catching the obstacles, catching myself, why am I doing that? Then I thought… lift your feet.

Interviewer

That in itself, up here (points to the head), now you're saying lift your feet because of one class coming here. So when you're out and about you might be coming to a curb at the edge of a pavement and you're aware that you need to lift your feet.

P06SS

Oh very aware. Very much aware.

Q.14. How confident are you that you will not lose your balance or become unsteady in everyday outdoor and indoor activities now that you have received some balance training? E.g. Up and down stairs? Standing on a high surface? Escalator in shopping mall? Quick turning?

Interviewer

Ok. Would you say that this has boosted your confidence now when you are out and about? So when you're doing your daily activities…

P06SS

Look son I'm very confident anyway. I've got all these things wrong but I don't um…

Interviewer

Let them effect you? Well that's a very good attitude to have towards life in general Cyril.

P06SS

As I say, the last twelve months or so, this kicked in. It's coincided unfortunately with that there (Staying steady classes). Well I'm doing this because of that. I'll tell you what mate I never bothered a doctor but as soon as that started, they all had their claws in me. But if you told me to do it, I'll do it. It's self-discipline Robin.

Interviewer

Right so you've always been confident, but, surely there are some types of activities that now you're not going to be as confident as you would have been in your younger days. Is there anything in particular that you can think of like getting on an escalator? Do you get on an escalator alright?

P06SS

Yes but I just catch a hold.

Interviewer

Just hold onto it. How do you feel if you had to hold a couple of bags and try to get on?

P06SS

Oh no. I just put it in one hand.

Interviewer

Exactly so did you already have that sort of thought to do that before you came to these classes?

P06SS

Not until I started with the falls right at the beginning I thought… gosh.

Interviewer

So is there anything in these classes helped and made you think about things like that to boost your confidence?

P06SS

Oh it's definitely helped. Made me more… back to my old confidence again. As long as I'm aware and I can. I mean if I had to just catch somebody I would end up bloody falling over, you know what I mean?

Interviewer

Right. Yes. So because of this raising awareness. He's telling you how to go around certain obstacles yea?

P06SS

And to avoid it yes. Oh yea. Oh it's made you think more about what you are doing. It's certainly very much sort of a casual thing. I'm now very aware of it.

Interviewer

Good. That's exactly what I think they want.

P06SS

I mean before it was automatic. Now when you're on your feet, you can't do it automatic anymore. You've got to consciously…

Interviewer

Ok. Right. But it doesn't stop you though does it?

P06SS

Not me. I told you.

Interviewer

I like hearing it. It's good to hear.

P06SS

You know what the chiropractor said to me, years now. “You’re the fittest man I’ve got for your age” (laughs)

Interviewer

Honestly you are. I love hearing that you are still out and about and you’re still doing everything. Don’t stop. Please don’t stop.

P06SS

I won’t.

Q.15. Is there anything else that this training has done for you that you would like to comment on?

Interviewer

So is there anything else you want to talk about? About the training at all? Anything you want to comment on? Do you enjoy having the social aspect in the class? I know you said you were shy.

P06SS

Yes I like all social aspects. Everything’s social.

Interviewer

How would you feel… if you didn’t have these classes…

P06SS

Oh I’d bury myself.

Interviewer

I mean if you had the option to do them at home, like the same sort of thing, almost like a trainer to come to your house to do it with you. Would you be as motivated to do it at home with a trainer as you would in a group class with other people to see what they are doing?

P06SS

Well I’ve always done everything on my own mate.

Interviewer

Ok so it wouldn’t affect you as such?

P06SS

No. I still feel like I’d get probably not as much benefit because I’m not remembering everything he has said you see that’s my trouble. That’s why I do the singing because I must keep it going. I’ll be singing all morning. No, seriously singing. Like… oh that ain’t quite right so I have a look in the book and… do it again. I keep this going because nothings worse. If you lose your… I mean my last partner had eight years of Alzheimer’s. Dreadful. I don’t think it’s because of not using the brain, I think it’s because something happens. You know, and there’s some reason for it.

Interviewer

It's like blockages in the brain isn't it or something like that.

P06SS

Oh no. No. It's like the cells start to die with Alzheimer's. It's like a stroke. A stroke obviously, physically knocks you about, but the Alzheimer's mate, I'm telling you it just comes. And there's a reason and they've got to find out. You've got to find out mate. I've got my theories on it. I think it's all the bloody petrol fumes about.

Interviewer

Well there's all sorts. There are all sorts of things that will contribute to it.

P06SS

Do you know they won't let them start a nursery now within so many yards of a road. Honest. I've got me ear to the… They're in for nothing. Listen mate, if the authorities told the general public, the world would be up in arms.

Interviewer

Yea they wouldn't would they. They wouldn't do that so.

P06SS

Atom power. Poison. We encourage it because we make the finest one in the world. Better than the Americans, better than the Russians so everybody buys ours, but if we fit it as we do then we are responsible for the… whats it called? So we have to get rid of it.

Interviewer

The nuclear waste or ?

P06SS

The waste. But that's plutonium. That's what it ends up as and that's worse than uranium so we've got to control it. Every ounce we give out comes back. That's why we're a dump because I'm afraid we've done, five or six years, there's four hundred and fifty all over the world. If you see on a map, nuclear power stations you think, oh. Its' covered the world because it's cheap.

Interviewer

But it's still dangerous isn't it.

P06SS

When that, what do you call it, Dounreay was open, I had a holiday on that coast and after about three or four years I started to see dead crabs on the beach and then, I went up there for thirteen years because the kids liked it and in the end there was hundreds of jellyfish and dead crabs washed up with the tides. They draw the water in off the sea to cool the reactor and pump it back out.

Interviewer

I’m just going to stop this here as I think we are finished with them questions.

Interview 5

Interviewer/Transcriber - Robin Tahmosybayat

Participant: P01SS

Location: Deckham Village Hall, Gateshead
Time: 30 minutes

Q.1.What are your thoughts on the training program? Did you enjoy it?

Interviewer

Right so tell me what are your thoughts on the classes so far? Have you enjoyed them?

P01SS

Yes I have. Yes.

Q.2. Anything specific that stood out about the training program? (Favourite game? Favourite movement?)

Interviewer

Ok. So your initial aim was to come to keep fit as opposed to train your balance?

P01SS

Yes well part of it was balance as well because you find as you get older your balance sometimes does get impaired and um… it was sort of like to maintain steadiness as well.

Q.3. How do you feel after a particular session during the training program?

Interviewer

Ok. Very good. So in terms of like a particular class… obviously you learn lots of things that you are well aware of already so it’s not really learning something new but there’s going to be some situations in classes where you’ve learnt something that you maybe hadn’t thought about?

P01SS

Oh yes. Yes.

Interviewer

Are there any of those things, in particular, like walking on your heels for example?

P01SS

Yes. I find that quite difficult but it does make you more aware of your body as well and how you can help to, you know, maintain your posture and be aware of things that can change it.

Interviewer

Right. Yea. Yea ok. And so… there are obviously quite a lot of things that you have felt good doing in the class and things you would have felt not so good doing in the class like maybe getting up and getting down from the floor like you did last Monday. Were you in last Monday? Yes you were weren't you?

P01SS

Yes. I was very apprehensive because I had fallen in the past and it was actually outside and when I went through, I did break some bones and I wouldn't want to go there again.

Interviewer

Hence why you are here (laughs)

P01SS

Yes. Yes (laughs). It was actually at the backdoor of the house and I actually forgot there was two steps but there was only one and down I went and it's the consequences of what happens but I wouldn't like to go through that again.

Interviewer

I don't think anyone would want to go through something like that again, of course not.

P01SS

Because I did have to have two types of plaster. It was actually this right foot and I still feel I have a weakness.

Q.4. Any aches or pains that have gone away? Have come back?

Interviewer

Ok well that was almost like my next question. Are there any aches or pains that you've had maybe at the start that have maybe gone away or haven't gone away or have been consistent?

P01SS

Yea, because of that fall I still feel that I have that weakness in my right ankle. Not that there would be anything wrong after having broken bones. I feel that it's taken quite a while, you know for it to get better.

Interviewer

I suppose bone is going to take longer than muscle and ligament isn't it.

P01SS

Yes. Yes.

Interviewer

I've broken a bone in my foot myself playing football years ago

P01SS

Oh yea? It's quite easily done. You don't realise.

Interviewer

So I got a moonboot and they try and encourage you to walk and I was a bit lazy to be honest and I didn't walk much. I had noticed just from not really pushing myself… I have noticed a bit of a weakness in my ankle still.

P01SS

Yes. I think you are left with that.

Interviewer

I don't think you necessarily are left with it. You have the opportunity to rehabilitate it.

P01SS

Yes well I'm six weeks in plaster and then they realise that due to the swelling that that initial plaster was too big and then when I went back after the six weeks I had to have, at the time, it was called fibreglass. I don't know if they still do it. But anyway, I had to have that on for six weeks as well and that was uncomfortable because it was quite tight and it dug into the back of my leg and also at the front so I actually had sores as well.

Interviewer

Nice. Very nice. Not very nice. No

P01SS

No. As I say I want to try to not go there again.

Interviewer

Try to avoid it again. So coming to these classes, obviously we are about half way through, well I think there is about eight weeks left.

P01SS

Yes.

Interviewer

And so Richies kind of progressed it week by week to make you do things that are probably a little bit more challenging. You know he is keeping an eye on the band. He's see if you are using your resistance band, he's going to give you the next one up. If you feel confident enough to move. If you feel the strength is increasing in your muscles. It's good to carry on with this sort of training all the time really.

P01SS

Yes. Yes.

Q.5. How does this compare to other types of training programs you have been a part of?

Interviewer

Have you done anything like this before? Or any other training programmes?

P01SS

No not at all. No.

Interviewer

Do you feel it's benefitting you in your everyday activities?

P01SS

Oh definitely. Yes. I feel a little bit fitter and I am more aware of when he tells you about, you know, outside, you know obviously pavements and curbs and things like that you have to be more aware of, which sometimes you carried on and you didn't take much notice.

Interviewer

Right. Yea like taking for granted.

P01SS

Yes. I found it very informative as well. The… information leaflets.

Interviewer

Yes the handouts you were given.

P01SS

Yes. Because you're not always out and about and knowing what's going on. It's always nice to have them to read back over, you know.

Interviewer

And do you read back over them at home?

P01SS

Oh yes. Yes. I think it's best to keep them for your own information because you never know when you might need to refer to something. So I've kept them altogether anyway.

Interviewer

Ok. And what about the… so obviously this class is a one hour class every week.

P01SS

Yes.

Interviewer

So that's what, sixty minutes of balance training or training shall we say. So the recommended amount of minutes is 150 minutes per week and so they say they want you to try and make up the rest of those minutes in your home exercises. About ten minutes every day. Ten to fifteen minutes.

P01SS

Yes I try and do that.

Interviewer

Ok so are you quite vigilant with it? Or you just do a bit here and there?

P01SS

When I remember (laughs).

Interviewer

Yep ok. So do you prompt yourself to remember? Like in the mornings or?

P01SS

Um… it' mostly afternoon. I mean after I've finished my housework and things and I think oh I'll just get the band out and, you know, have a five to ten minutes and I like walking most days. I think that is good exercise.

Interviewer

It definitely is yes. Do you find that you are referring to the movement booklet that they gave you for the home exercises?

P01SS

Yes, the sitting. The sitting helps.

Interviewer

I mean I'm sat here with terrible posture (laughs)

P01SS

(Laughs)

Yes I mean there certainly is a lot of um… you don't realise that you do it sometimes. You know if you're sitting watching the television and you sort of start to, you know, slump.

Interviewer

You kind of just go like that don't you (actioned slumping forward). It's natural though. It depends on the type of chairs you have in your house and things like that as well doesn't it.

P01SS

Yes. Well I tend to pick the sofa because it's the comfiest you know.

Interviewer

Anne I think everyone picks the sofa (laughs). I don't think people want to be sat up watching TV like this on a night time.

P01SS

Oh it's the best.

Q.7. Would you do it again?

Interviewer

So obviously we still have eight weeks to go but if you had the opportunity to do this type of course again or if you were allowed to do it on a rolling basis would you do it?

P01SS

Yes I would. I'm looking for something, you know, like after this session and I wondered would there be another one, obviously it wouldn't be a repetition of what we've done. I'm looking at something further now and possibly, I was going to write down about this class.

Interviewer

This one? This class? Yep. Well you have just bear witness to it. You have just experienced it. You know?

P01SS

Yes.

Interviewer

I think this programme compliments the staying steady classes. As in, where the staying steady course finishes, it's like circuits, so it's basically this. This is a perfect way to sort of follow on from that programme.

P01SS

Some people that have done the posture and ability carried on to do this?

Interviewer

Yes as far as I am aware I think they have yes.

P01SS

Because what I wasn't sure about was… this is like the beginning, and then obviously Richard will be taking another 20 weeks after that which will be a repetition of what we have been doing. So… you can't sort of come back and do all that?

Interviewer

Yea I don't think they let you actually. Because it's a free course, I think once you've done the course once its…

P01SS

Open to other people.

Interviewer

Exactly. I think that's why he is getting everyone to search, yes search for what amenities they have at their disposal. So they can carry on this lifestyle, one hour per week, going somewhere and doing this sort of exercise.

P01SS

I think it's a good idea.

Q.8. What would you change about training program (Exergaming, Staying Steady) console, game) to make it more engaging?

Interviewer

Yea? Definitely. So the questions I'm going to ask now are based on the questionnaires that I gave you to fill out before and after the balance training. So, if there was anything, what would you change about the balance training program or the classes to make it more engaging for yourself… to train balance?

P01SS

Oh I don't think there is anything. I think they have covered quite a lot in the last few weeks. I think this last… on Monday sorry, on Monday I felt that I was more able to do the exercise. When I came in on the first time I had a go at getting down on the mat.

Interviewer

In the first class?

P01SS

Yes in the first class. It was a bit frightening and obviously there is a right way of getting up and I've achieved, I think, it better on Monday.

Interviewer

Ok yes. So that's evidence in a way isn't it?

P01SS

Yes.

Interviewer

That's saying… look week one, I tried to go down to the floor and get back up again. Week twelve, I think we are, so you feel more confident doing it now.

P01SS

Yes. Yes.

Interviewer

Ok. So that's physical evidence of an improvement almost isn't it?

P01SS

Yes. I feel that I could move my limbs better, you know, my legs and that better.

Interviewer

So like, your mobility?

P01SS

My mobility has increased yes.

Interviewer

Brilliant. Ok. So what about it being as a group dynamic in the class?

P01SS

Oh I enjoy that.

Interviewer

You like it? The social aspects of it?

P01SS

Yes. I think they're quite a good bunch.

Interviewer

Yea they're not bad are they (laughs)

P01SS

(Laughs)

I suppose. Could be better but… (laughs). No I enjoys meeting different people that have the same, you know, need.

Interviewer

Well you're all in the same boat in a way.

P01SS

Yes.

Interviewer

At different levels. Everyone's at different levels.

P01SS

Yes. Some of us are more able than others.

Interviewer

Yes but that's in everything though isn't it.

P01SS

That's right. Yes.

Interviewer

Would you say the social connectedness helps you… motivates you to come to the classes at all? Or do you think you would come anyway?

P01SS

Yes I enjoy the company. The different company and meeting different people. Its enjoyable yea.

Q.9. What are your perceptions on safety of using this method (Exergaming/ Staying Steady) to train balance? (Self-efficacy) Were you anxious at all during training? (Anxiety)

Interviewer

So what are your perceptions on safety of the classes? Do you think that they execute the class in a safe manner? So the way that they run the classes? Do you think its done safe enough for individuals?

P01SS

Yes. Yes because I think it's good that actually Richard shows us the right way to do it in the first place rather than us going ahead and trying to do it ourselves. The safety thing is if you watch somebody doing it the right way, you know, I think it helps.

Interviewer

Yes because you might have your own version of what you think is the right way.

P01SS

Yes and it could be incorrect.

Interviewer

And often I've seen in the classes some people helping each other in that respect like "no don't put your foot here" and "you have to do that".

P01SS

Yes. Yes.

Interviewer

Ok brilliant and so you think that the classes are led safely as well? When they do the demonstration. It's followed up by education.

P01SS

Oh yes. Yes.

Interviewer

Ok. So does that have any impact on anxiety? Did you feel anxious at the start of the course?

P01SS

I did actually because you're not aware of what actually is going to happen and as we've progressed I think it gives you confidence when you know the right way to do things.

Interviewer

Yes ok. So that's almost like an initial thing as well? As you don't know what you're getting into but as you become more knowledgeable, an expert as he was saying on Monday then you do feel a bit less anxious would you say?

P01SS

Yes. Yes. That's right.

Interviewer

So any particular movement that made you feel anxious at the start?

P01SS

It was the thought of getting down on to… but obviously we have the mats, it was the thought of falling on the hard surface. I would do things differently. If it was to happen now, I would be doing things differently. I can see that what he has told us that it would be easier if you know the right way. Easier to get up.

Interviewer

So more awareness of the situation as well. So first things first when you fall down it's a pride thing. So everyone wants to get back up because they are embarrassed.

P01SS

And you don't want… and also you have to take your time because you feel that you've been down there and you've got to get up as quickly but you don't have to.

Interviewer

No unless obviously you're in the middle of the road.

P01SS

Yes if you're stopping all the traffic.

Interviewer

You can't just say "stop there, I'm seeing if I've got any pain in my legs" (laughs)

P01SS

Yes (laughs).

Q.10. Were you conscious of the movements being conducted during your training session? Where was your attention? Did you enjoy the experience? Worried about performance? Did you feel in control?

Interviewer

Ok. So in… obviously a particular movement in the class or a particular class in general, were you conscious of the movements you were doing? So… was your attention on… right so I need to stand on my heels now, I need to maintain my balance or were you thinking about other things whilst you were doing the movements?

P01SS

No I was trying to concentrate on what I was doing.

Interviewer

Ok. Ok.

P01SS

And trying to do it, you know, to my best ability. Because you can't always do it straight away. It takes a little bit of time to get used to that. If you haven't done, as you say, on your toes, it's not very often you're wandering about like that, it's not a normal thing to do and then you have to be aware you know that you can do it if you have to.

Interviewer

Right ok and so your attention was on the movement you were doing at the time

P01SS

Yes.

Interviewer

At times was your attention… well obviously it must have been on Richie at times when he was explaining things whilst you were doing the movements as well. So a little bit diverted to the class instructor.

P01SS

Yes because you are a little bit conscious about knowing about your next thing you've got to do. You know but obviously it's under instruction isn't it so you have to listen.

Interviewer

Yes exactly. Yep. At any point were you worried about your performance in the class? So when maybe you're looking at other people? Did you think… I'm worried about my performance in front of these people? Or I'm not worried at all.

P01SS

No it doesn't worry you as such because you try and do the best that you can. I think that's all you can do.

Interviewer

That's all you can do.

P01SS

You do have a tendency while you're doing the exercise to look at other people because you think… well are they doing it, you know. You just do it to your best ability and you can't do anything more I think. Unless somebody says you're doing that wrong, you know, and they correct you, which I wouldn't mind. I wouldn't mind anybody coming to me and saying… yes you've done something wrong.

Interviewer

Ok. Right. It wouldn't make you worry about your performance?

P01SS

No. No because I would prefer to know.

Interviewer

Yes because it's helpful isn't it?

P01SS

Yes. Yes.

Q.11. How do you feel the training program impacted your level of fatigue? How did this impact your motivation to train?

Interviewer

Ok. Right so now I'm going to talk about fatigue and levels of fatigue. Ok so the training program is about twelve weeks in. At the start of the program compared to now, would you say that you feel less fatigued in your everyday activities?

P01SS

Yes I actually feel a little bit more fitter than what I was and so I think it has done me good.

Interviewer

That's an added benefit of the class as well. It's not just your balance but your all round fitness.

P01SS

Yes. I was getting a bit lazy actually, you know, you do I think sometimes. I mean I know the time of year.

Interviewer

Yes because we've had the Christmas break haven't we.

P01SS

Yes and then if the weather's not so good you don't go out so much. You know but hopefully that will pick up.

Interviewer

Right yes and has that decrease in your level of fatigue, do you think that's helping to motivate you to come back to the classes?

P01SS

Yes because I think you've got to get up and get going.

Interviewer

Yea? And does it help you to train balance in particular?

P01SS

Um… yes I think you are aware of… I mean I tend to stoop a bit but I think you know, age-wise as well, but that can happen but um… but that's a family thing as well.

Interviewer

Yes. Ok so everyone kind of goes like that (demonstrates stropping)

P01SS

Yes the doctor told me my posture was all wrong and at one time they advised me to do yoga

Interviewer

To be able to bring the shoulders back more? What does this mean?

P01SS

I didn't think I'd be able to do that. That again I thought was the getting down, you know, and it just didn't appeal to me.

Interviewer

Ok. Well I mean it's what Richie kind of said. You've got to go and do the things you kind of enjoy. If it doesn't appeal to you

P01SS

You don't do it.

Interviewer

Exactly. You're not going to try as hard at something you don't enjoy are you?

P01SS

No.

Q.12. Did the training program feel negative in any way in terms of your self-thoughts? (Negative self-talk) Did you feel absent during the program? Could you sleep ok? Slowness of thoughts? Angry?

Interviewer

So did the training program, I say the training program but I'm referring to the classes here. Did it feel negative in any way in terms of your self-thoughts?

P01SS

No. No I think a lot of it is positive.

Interviewer

Brilliant yes. Well I think that's the idea isn't it.

P01SS

Yes. Yea.

Interviewer

So no feelings of absence during the training at all? Like in the class did you feel like?

P01SS

Like I cannot be bothered with this?

Interviewer

Yes. Did you feel like that?

P01SS

No. No.

Interviewer

Ok. Brilliant. What do you think that is down to? Do you think that's down to the way the class is led? Or down to it being a group? Or is it all of these things or none of these things?

P01SS

Well I would say it's coming here, meeting people, knowing that you've got somebody that is helping you to achieve something different and I enjoy it.

Interviewer

Brilliant. That's what I was going to say. So obviously you enjoy it. Have the classes influenced your sleep patterns at all? Like do you sleep better now? Worse now? Have you realised any differences in your sleep patterns?

P01SS

Not really. Well there again it's the time of year. I find I can sleep a lot longer but you are aware that's a seasonal thing. We all feel better spring and summer. No as I say I have enjoyed every minute of it.

Interviewer

Fantastic. Brilliant.

P01SS

I think it's nice to have something that they look at this type of thing for people, you know, like of our age as well.

Interviewer

Yes it's focused on your age group as well isn't it? So the way that they designed the program is in consideration, yes, yes exactly.

P01SS

Yes they look into all that.

Interviewer

Ok so no feelings of anger. Ok. Brilliant. No feelings of anger or slowness of thought or anything like that as well?

P01SS

No.

Interviewer

Ok. Fantastic. Good to know (laughs). Don't want angry people up here.

P01SS

No (laughs). Some people do have that thing where they have got to get it out, but it's not the place is it?

Interviewer

Well I suppose that depends on the person, doesn't it?

P01SS

Yes.

Q.13. Can you tell me how you feel when you go about everyday activities? Are there any fearful moments you have or concerns when you are out and about? (falling over)

Interviewer

Ok so now when you go about your everyday activities, so once you have done your housework and you say you go out for a walk, did you used to have any fearful moments when you were out walking? Or when you were pottering around the house? Like falling over for example.

P01SS

Well it had been some time since I had fallen over and I'm more aware of the situations. I actually take more time.

Interviewer

Is that because of the classes that you are aware of that?

P01SS

Yes. Yes because doing a little bit of activity and then having a break. I like doing the garden but I feel that I don't rush and do something because that's what happened. I rushed to do something before and that's why I fell and I'd never fallen.

Interviewer

And that's almost like a lesson that's continued throughout these classes where Richies like take your time.

P01SS

Take your time yes. Slow down because we do think we're still able to do what we did years ago (laughs) and we cannot.

Interviewer

It's like you can but it's going to take you a little bit longer now.

P01SS

Yes.

Interviewer

So would you say that the fear of falling over has kind of decreased from when you started?

P01SS

Yes.

Interviewer

And that's attributed to coming to these classes and learning from other people and from Richie and from yourself.

P01SS

Yes. Yea that you have to take more time. But I mean the signs that you are older, you have to adjust to things differently.

Interviewer

Absolutely yea. That makes sense and… it's not a bad thing either.

P01SS

No. No. Its…

Interviewer

Awareness is important I suppose.

P01SS

Yes. That's right. Yes and I'm more aware of things outside.

Interviewer

For example?

P01SS

You tend to look at things more so. I don't know why. You know, sometimes I used to wander about and not think about the situation but now because there's sometimes like obstacles appear quicker and you think, oh, you do have to pay more attention. You know if your body had been slowing down a bit, you know, gradually go along. You have to sort of adjust to that I think.

Q.14. How confident are you that you will not lose your balance or become unsteady in everyday outdoor and indoor activities now that you have received some balance training? E.g. Up and down stairs? Standing on a high surface? Escalator in shopping mall? Quick turning?

Interviewer

So how do you think that would influence your… so this is almost a similar question in nature but from the opposite end of the scale. So not from the fear of falling over, but how has it influenced your balance confidence? So from the start of the training to now. Would you say you are more confident in your ability, in your balance whether it's doing activities in the house, whether it's walking outside during winter when it's icy, getting onto an escalator, you know, when you've got other things in your hands, doing a few different tasks so like coordinating at the same time. Do you feel more confident?

P01SS

Yes. Yes. I have to take more time.

Interviewer

Yes so like what we were saying, taking more time.

P01SS

And prepare, you know, more. I mean I don't like escalators at all. I used to sort of go at it too quickly but now I sort of, you know, if I'm at the Metrocentre, I stand back and I make sure I have everything in one hand to ensure that I know that if my balance in impaired in anyway that I do have a free hand.

Interviewer

To hold onto the rail.

P01SS

To hold on. I do tend, if there's something there now, I do tend to get a hold of it because it's there to help you.

Interviewer

Do you think that's something that you have learnt from these classes then?

P01SS

Yes. Yes.

Interviewer

Would you say that's more attributed to the education part of the class or the balance training part of the class?

P01SS

I think it's the balance training more so because sometimes you can be unsteady on your feet for numerous reasons but I find um… if like getting off the bus and if it helps I find its better to use the equipment if it's available.

Interviewer

That's why it's there isn't it.

P01SS

But you do feel, you know, like you're able to do it without but then I think it's better to use it whether you need it or not, it's better to use it because at least you know you're going to have that steadiness.

Interviewer

Yea like support.

P01SS

Yes support.

Q.15. Is there anything else that this training has done for you that you would like to comment on?

Interviewer

Right ok. Brilliant. So is there anything else you'd like to say about the classes that you have enjoyed or that you'd like to comment on?

P01SS

I think they are a good idea. Um… it does make you aware more of situations that you're going to encounter and I think that if you didn't know, obviously that's when the fear comes into it, if you don't know how to put things right or correct it and then it's all to do with learning isn't it.

Interviewer

Absolutely. Definitely I think it's…

P01SS

And the way society is nowadays, it's changing that much. You know, I think um… you know like compared to years ago, I don't think there was such a thing. The classes.

Interviewer

Well there's also this portion of the population in your age category, well not your age category, a bit older so 85 plus, that's the fastest growing part of this population so that's why there are a lot more of these classes that are designed to help you live healthier lives now and its going to prolong your lives, well not necessarily, there are always external factors but..

P01SS

But the fitness part.

Interviewer

In terms of your wellbeing, your health, your balance your coordination, keeping that brain ticking, this is why they are putting them into communities to kind of, the more you move the better really.

P01SS

They better because we could all get to the stage of couch potatoes, couldn't we? And it's not good.

Interviewer

It's not good no. That's always linked with a less longer life.

P01SS

Obesity.

Interviewer

All of those sort of things yea. So there's nothing else really that you'd like to say or..?

P01SS

Well as I say I just find it a very good idea and I'm glad that I went to the library on that particular day.

Interviewer

Right. That's how you heard about it?

P01SS

Yes and it hasn't been to any disadvantage. I think it's been more to an advantage.

Interviewer

Brilliant. Yes. Fantastic. That was it that was the end of the interview so thank you very much.